# Lessening bus journey times on congested road infrastructures: micro-modelling methodology. Case study in the region of Liverpool, United Kingdom

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# LESSENING BUS JOURNEY TIMES ON CONGESTED ROAD INFRASTRUCTURES: MICRO-MODELLING METHODOLOGY

CASE STUDY IN THE REGION OF LIVERPOOL, UNITED KINGDOM

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[Summary]
Within the framework of their Local Transport Plan (LTP), a five-year transport programme running until 2011, authorities of the British Metropolitan County of Merseyside are seeking for ways to provide their territory with a safer, more reliable and more sustainable transport network. The key target is to mitigate congestion on the strategic road infrastructures, through a significant lessening of global journey times. In that purpose, elaborate microsimulation models are required to be built for eleven representative roads of the county, allowing to carry out relevant traffic testing and further analyses.

This document deals with one of the key routes' modelling process: the A552 corridor of Birkenhead, one of Liverpool's neighbouring cities. It depicts precisely the utter building methodology which was has been used to lead to a reliable and highly detailed model, from the preliminary context study to the final model validation, and allows to observe how meticulous and painstaking the procedure must be.

The work's ultimate aim reckons bus users in particular: a range of options and scenarios testing will be subsequently achieved, to find out possible improvements regarding bus journey times. These tests, that will be reviewed through later reports, will be made possible thanks to the model considered in this document.

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| **[Résumé]**<br>Dans le cadre de leur Plan Local de Transport (PLT), un programme de cinq ans destiné aux transports courant jusqu'en 2011, les autorités du comté métropolitain britannique de Mersyside recherchent des solutions visant à doter leur territoire d'un réseau de transport plus sûr, plus fiable et plus durable. L'objectif principal est de parvenir à maîtriser la congestion, au moyen d'une baisse significative des temps de parcours globaux. Dans cette optique, des modèles de microsimulation doivent être élaborés pour onze routes représentatives du comté, afin de pouvoir procéder aux tests de trafic et aux analyses nécessaires.<br>Ce document est dédié au processus de modélisation de l'une des routes clés : le corridor de l'A552 de Birkenhead, une des villes voisines de Liverpool. Il décrit précisément toute la méthodologie employée en vue de parvenir à un modèle fiable et hautement détaillé, depuis l'étude de contexte préliminaire jusqu'à la validation finale du modèle, et permet d'observer à quel point la procédure doit être minutieuse et soignée.<br>Le but ultime de ce travail concerne les usagers de bus en particulier : une série de tests basés sur différentes options et scénarios sera achevée ultérieurement, afin de déterminer les améliorations possibles concernant les temps de parcours des bus. Ces tests, qui seront passés en revue au travers de rapports subséquents, seront réalisables grâce au modèle considéré dans ce document. | | |
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# Summary

# Introduction

This document is reporting on the work carried out within the framework of a project ordered by the metropolitan county of Merseyside, United Kingdom. This political and geographical entity, which includes five metropolitan boroughs adjoining the River Mersey Estuary in the North West part of England embraces, according to the mid-2006 Office of National Statistics (ONS) estimates, more than 1,400,000 inhabitants. Its core, the city of Liverpool, is a major economic centre gathering about 400,000 dwellers and constituting an agglomeration area of about 800,000 inhabitants. These characteristics make Liverpool one of the five most populated cities of the United Kingdom and a part of the ten most important urban areas of the country along with London, Birmingham, Manchester, Leeds, and Glasgow.

Merseyside decision-makers have to deal with the recent Government's Public Service Agreement (PSA), published in 2004 for the 2005-2008 period. This fundamental agreement implements new objectives for all strategic public services such as education, health, defence, environment, justice, culture, and obviously transport. The Government's commitment is basically aimed at providing services able to sustain economic growth, while seeking to improve their efficiency and, when relevant, make them more respectful to the environment.

Each Department of the Government has received specific instructions related to its field of intervention. The Department for Transport (DfT) has hence encouraged the authorities of the main urban areas to introduce a Local Transport Plan (LTP) that must be applied locally, on counties, boroughs and urban agglomerations scales. The first global recommendation expressed by the government entity regarding these LTP is to make journeys more reliable on the strategic road network.

Merseyside, following the Government's policies, has also published a five year Local Transport Plan which is running until 2011 : this £230m delivery programme of transport investment and service improvements aims to give Merseyside a safer, sustainable, efficient and integrated transport network, accessible to all users. The partnership, whose plans include all available means of transport within the local territory (cars, buses, trains, motorcycles, bikes, pedestrians) includes the submission of new plan to the Government every five years. Thus Merseyside's general vision of transport system for the future is "a fully integrated safe transport network, which supports economic and social regeneration and ensures good access for all, and which is operated to the highest standards to protect the environment and ensure quality of life".

Among the huge amount of factors which determine whether a transport system is reliable or not, the road congestion monitoring takes up a privileged place in the eyes of Merseyside authorities. A network penalized by unceasing saturation not only prompts an erosion of the regional relative competitiveness, but also a deterioration of the quality of life in the area when considering, in the middle of other undesired consequences, the rise of green house gases rejected in the atmosphere in situation of saturated traffic.

Given these congestion mastery preoccupations, the central variable that will be used throughout the study will be the journey times. Journey times, either considered globally for all the users of the network, or at the scale of defined users classes (motorists, public transport users, motorcyclists, cyclists, pedestrians) inform in a very relevant way of the saturation level on the road infrastructures. They represent an inescapable lever within the framework of implementing policies aimed at allowing more fluid trips in a more effective and reliable network.

The journey times are obviously expected to be as low as possible in the context of the Merseyside LTP's congestion monitoring purpose. But from the last twenty years, according to diverse local and national statistics, the number of trips made within and around the area has been rising significantly, car ownership and use has been progressing linearly, while travelled distances have been increasing in certain areas of the county, resulting in a global traffic rise on the main roads. Travel demand is reaching, and probably going beyond the major transport infrastructures' maximum capacity. Therefore current global journey times are no longer deemed satisfying enough to cope with the new reliability and effectiveness recommendations.

The main target of the Liverpool area LTP is then to reduce journey times for all users of the road infrastructures. A national congestion target has then been set over the LTP period, which applies to the country's ten largest urban areas. The target is a measure of average person journey time on a number of selected highway routes within the areas. In Merseyside, eleven routes were selected to represent the area's most congested infrastructures. As part of the current LTP, journey times on the eleven routes are monitored and reported on annually. The Dft requires each urban area to demonstrate how the target was to be met, and detailed models are hence being built for the key routes in order to allow for testing of the most effective means of influencing journey times, in case of varying and unpredictable traffic changes.

The report will be focusing on one of these key routes, whose model has to be built in its entirety to be able to respond to the study's objectives. This route is the 4.2 km (2.6 miles) long main corridor of the Wirral's District city of Birkenhead, located in one of the five districts the Merseyside perimeter holds. The infrastructure, designated as A552 in the UK road nomenclature, joins Birkenhead and its agglomeration, the second most populated in Merseyside after Liverpool's (more than 300,000 inhabitants from the latest ONS Census in 2001), to the Liverpool area.

The document will be markedly dealing with one specific user class among the totality of the infrastructure's users: public transport passengers. The corridor is currently crossed by a consequent number of bus services, allowing their patronage to travel through Birkenhead and join the major local geographic poles such as the Birkenhead city centre or Liverpool. But it is disquieting to observe, in the latest Wirral

District statistics, how regular has been the drop-off slope of bus services use in the area from the last twenty years, while the car modal part increased exponentially.

The likely last decades' bus travel times enhancements and loss of competitiveness against other means of transport, correlated with the substantial traffic and congestion rises on major roads, are obviously not the only reason of the slumping plebiscite of public transport. But attempting to reduce global bus journey times, crucial criterion of the bus services' effectiveness, could allow making public transport trips much more attractive in the eyes of their current and potential users. It is important to remain considering the huge potential demand which exists for these services, a demand that needs to be better still encouraged by providing competitive performances. This issue constitutes then a particular stake of the project, whose purpose is ultimately to try to demonstrate how bus journey times can be affected to become decreasingly long, even on a congested infrastructure, in order for Merseyside decision-makers to finally know their range of relevant actions.

To allow carrying out the appropriate traffic testing, and achieving all necessary analyses regarding buses operations, the study area needs to be meticulously reproduced with relevant tools. The virtual replication of real and complex interactions between different vehicle types is indeed possible, through a highly thorough procedure, supposed to lead finally to a valid and trustful microsimulation.

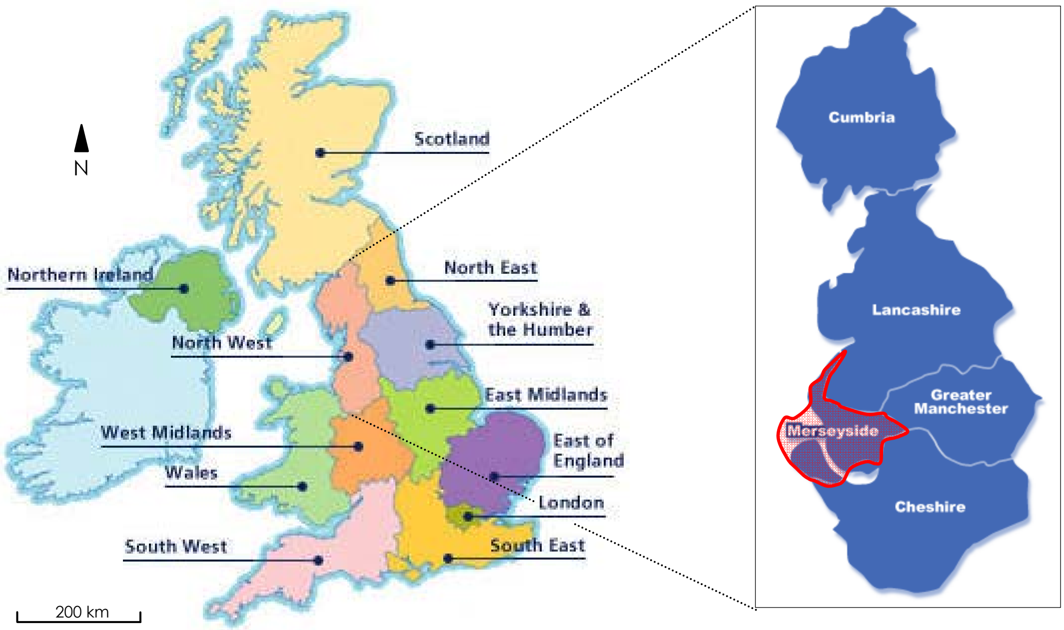
This document will hence be exclusively devoted to the various stages that have ended at the Birkenhead corridor model's validation. It will be reviewing the whole methodology used from the very first stage to the last one: all building steps, necessary databases, assumptions decided and justifications. It will also pay a constant attention to the local context within which the study takes place. The ultimate objective is to demonstrate how such a replication can be made reliable enough to cope with the elaborate forthcoming testing (whose description will not be included in this work, as they will be the subjects of subsequent reports to deliver once all eleven routes' models will be achieved).

The document will be divided into four parts. The first will be situating the study in its geographical environment, and focus on Merseyside's geographical, political, economic and demographic characteristics. The second will be dealing exclusively with the different transport systems available over the Birkenhead area, and will be pointing out its dwellers' global behaviours regarding transport. As for the third and fourth parts, these chapters will be concerning the utter model building procedure: part three will be focusing on the virtual reproduction stages carried out in the microsimulation software, when part four will be describing precisely the transport demand estimation that will be used in the model over the subsequent testing.

# Part 1. The metropolitan county of Merseyside: geographical, political, demographic, and economic specificities

The metropolitan county of Merseyside is one of the five counties comprised in the North West region of the United Kingdom, along with Cheshire, Cumbria, Greater Manchester and Lancashire (Map 1). This region is the third most populated amongst the country's twelve areas with 6,853,200 inhabitants[1], after the South East (8,237,800) and London (7,512,400) regions. Its density of population (475 persons per square kilometre) is the second highest, far from London's 4,758/km² huge rate.

**Map 1: Merseyside and the North West region of the United Kingdom**




*Sources: http://www.autoindustry.com, http://www.conferences-uk.org.uk*

In this part of the document, Merseyside territory and population will be depicted, as well as its governance system and economic characteristics. The District of Wirral which houses the city of Birkenhead, core place of the study, will be particularly observed.

## *1.1. A sub-national territory with scattered political governance*

In the United Kingdom, counties are the second tier of the sub-national geographical split, after the regions. Each region is divided into several counties whose types can be either metropolitan or non-metropolitan. Only six metropolitan

[1] *mid-2006 estimates*, Office of National Statistics, 2007.

counties are numbered in the country, constituting a largely underrepresented group in the midst of all the bodies as they cover the main urban areas of the national territory (*e.g.* Liverpool, Manchester, Leeds or Birmingham, whereas London is covered by the Grater London region).

As far as Merseyside is concerned, its surface area embraces five districts, also called metropolitan boroughs: Liverpool, Knowsley, St Helens, Sefton and Wirral (Map 2).

**Map 2: The Merseyside territory**

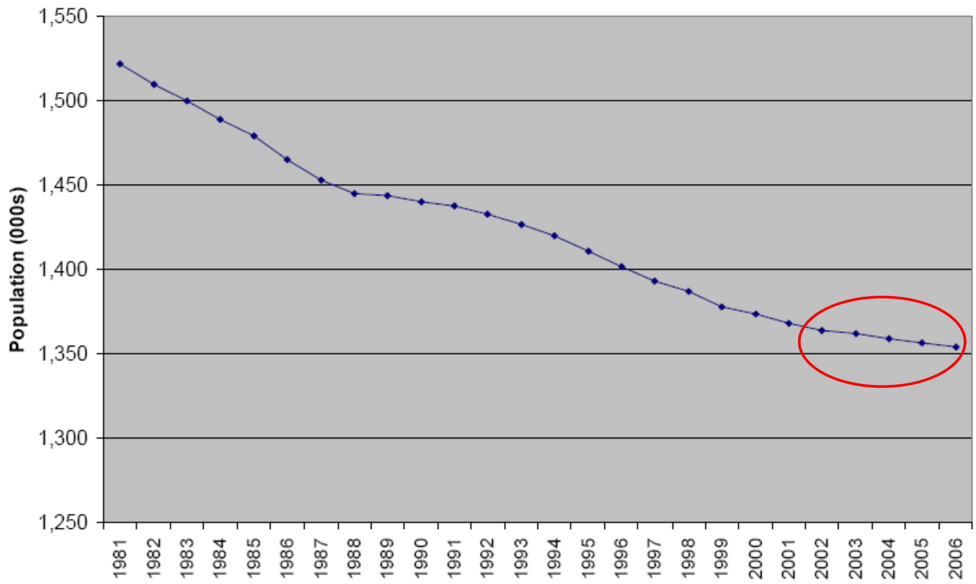

*Source: www.britishservices.co.uk*

Even though Merseyside is existing as a geographically delimited territory, created in 1974 after the publication of the Local Government Act of 1972 and still registered in law, the area is nowadays devoid of political authority: its former executive arm, the Merseyside County Council, has been abolished in 1986 along with all other county councils under the Margaret Thatcher's Government. Most of the county's functions have then been transferred to the metropolitan boroughs, making them unitary authorities managing the local public life as part of a one-tier administration (replacing the former two-tier system, with the county council sharing its functions with the district councils). The remaining county-level services, like police, fire and rescue, or waste treatment, are now taken over by a joint-board administration shared by councillors from the five districts. Public transport organization and development are also still administered on the Merseyside scale, with the Merseyside Passenger Transport Authority managing the local public transport brand: the Merseyside Passenger Transport Executive (MPTE, or Merseytravel).

## 1.2. Economic growth and expected demographic regeneration echoing local attractiveness

In their latest economic review[2], Merseyside political actors are delighted to claim the county currently shows evidences of growth and investment. Key indicator of economic vitality, Merseyside population has again maintained a very slight decrease in 2006 from the ONS mid-2006 estimates, consolidating hopes of a long-term demographic improvement in this county embracing presently 1,353,600 dwellers (Figure 1). After the late 20th century's consequent outflows, which have seen population total plummet from 1,718,000 in 1971[3] to 1,368,000 in 2002 and reflect local economic weaknesses, current statistics evidence regional attractiveness has been showing steady signs of progression since then. This emigration decline is actually led by a substantial rise of the young working age population (according to the ONS, working age population refers to men aged 16 to 64 and women aged 16 to 59), especially the 20-24 age-band, expressing the ongoing interest from students and young workers towards the Liverpool region.

**Figure 1: Merseyside population, 1981-2006**




*Source: Office of National Statistics (2007)*

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[2] *Merseyside Economic Review 2007: Summary Report*, The Mersey Partnership, Liverpool, 2007.

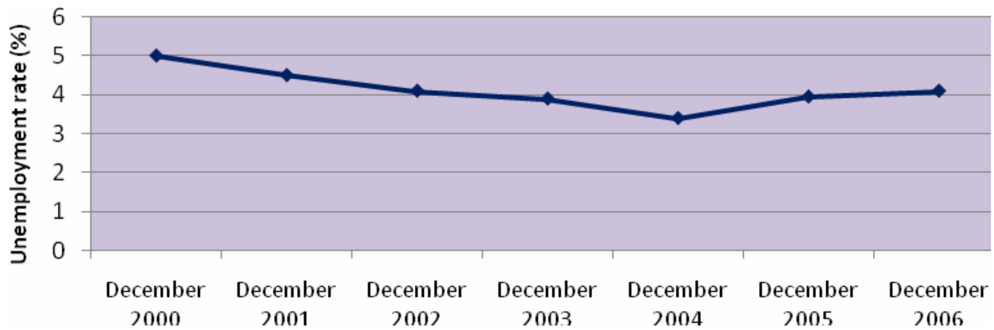
[3] *Population Censuses*, Office of National Statistics, 1971-1991.

The age-bands whose quantity has been slumping the most significantly are the under-15 and, in a much more consequent way, the 30-39. The outflows observed for this people are expected to be offset by the important working age population's arrivals, but local authorities are nevertheless concerned about knowing how to preclude the exodus of the 30-39, which have dropped by 11% between 2003 and 2005. In comparison, the North West region experienced a 9% decrease for this age-class over the same time period. This figures suggest people are rather massively leaving Merseyside at certain career or life points, seeking for still more attractive regions for professional or private purposes.

This issue does not darken the global positive observations regarding Merseyside's economic situation, all the more since its Gross Value Added (GVA, equivalent to the Gross Domestic Product plus the difference between taxes and subsidies on products) has grown by 5.6% from 2003 to 2004, reaching £16.1bn according to the authorities. Just beneath the North West region (5.7% growth) and the United Kingdom (5.9% growth) performances, the Liverpool region's figure shows the gap separating Merseyside from the rest of the country is more narrow than it has ever been, mainly due to a very strong 2000-2003 period (disappointingly followed by a reversal this very recent years). And the individual output, the GVA per head, has even grown as much as the UK's one (5.5% between 2003 and 2004, to hit £12,448) and marginally faster than the North West's one (5.4%). These encouraging values result from the range of Merseyside and its districts decision-makers' policies intended to attract firms and investors, which have been conducted from several years.

As far as the employment is concerned, Merseyside still shows itself fairly competitive: even though it has risen by 0.3% from late-2005 to late-2006, the unemployment rate was maintained at a low level of 4.1% at the end of 2006. As the next figure shows, Merseyside experienced a regular slumping unemployment rate over its efficient 2000-2004 period before observing slightly higher figures from then on (Figure 2). But the current unemployment situation remains anyway conspicuously better than the 2000 one.

**Figure 2: Merseyside unemployment rate, 2000-2006**




*Source: Office of National Statistics (2007)*

Merseyside unemployment rate is actually equivalent to roughly 37,000 persons. Its 4.1% figure remains appearing less competitive than North West (2.7%) and UK (2.5%) statistics, which still provides local political actors with the same stakes regarding the Liverpool region's economic efficiency.

Local employment statistics also show evidences of Merseyside's economic vitality (Figure 3): still reflecting the narrowing gap between the river Mersey districts one the hand, and the North West region and the UK on the other hand, figures show a local working age population in employment increasingly high, reaching 68.2% in 2005 (compared to the 67.3% count of 2003) when the UK rate fell slightly to 74.3 % and the North West's one was maintained in the vicinity of 72.6 %. And the economic rate, which reckons the working people added to those unemployed but seeking work and available to work (and also the students having paid employment), amongst all working age persons, attains 73.1% in Merseyside, close to the North West's 76.5% and the UK's 78.3%. This allows Merseyside authorities reveling in the fact they are managing to bring levels of economic activity vibrancy up to the national figures.

**Figure 3: Employment and economic activity Rates, 2006**


*Source: Office of National Statistics (2007)*

In terms of employments and people gatherings, the county's major area is the city of Liverpool and its suburbs: 436,100 inhabitants are grouped within the Liverpool borders according to the ONS' 2006 estimates, and about 816,000 dwellers in the whole Liverpool Urban Area (which includes the contiguous built-up area beyond Liverpool on the eastern side of the river Mersey, in the Boroughs of Knowsley, Sefton, St Helens and even the outer-Merseyside District of Haydock). In the city of Liverpool, whose most representative age class are the 15-29 (23%), the 30-44 (22%), and the 45-59 (17%), it emerges that roughly 97% of the persons are living in households (against only 3% in communal establishments) and are sharing a relatively stretched urban space.

In this economically dynamic port city of nearly 38,000 students, the main employment sectors are wholesale and retail trade (16%), health and social work

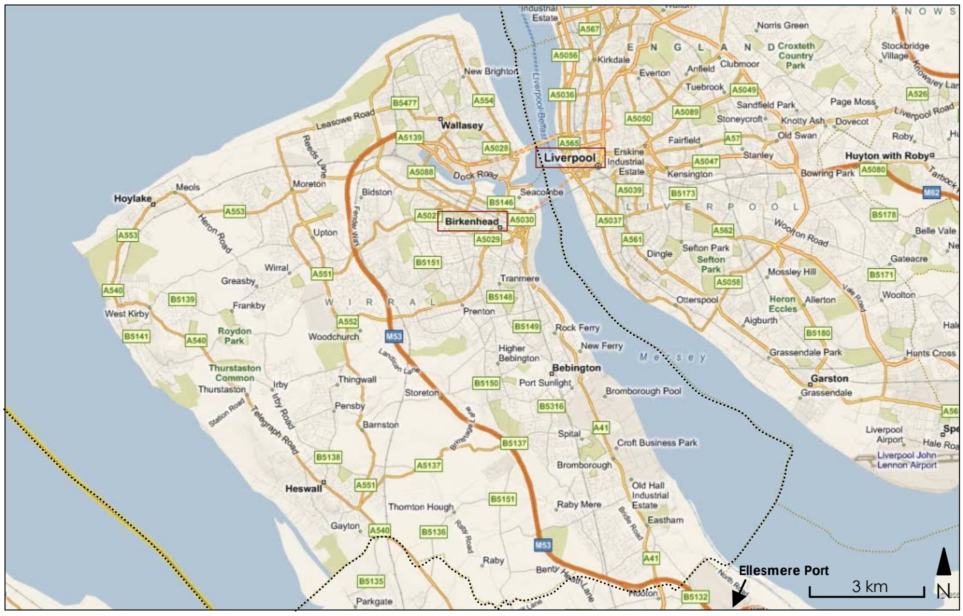
(15%), manufacturing (11%) and education (10%). Its £5.6bn[4] GVA is the first in Merseyside, and its GVA per head experienced the fastest growth within the county in increasing by 5.7% from 2003 to 2004. Liverpool represents now 125% of the Merseyside average GVA per head and 103.6% of the North West average.

## *1.3. The Wirral Metropolitan Borough and its core Birkenhead*

As the study is particularly focused on the area of the Birkenhead city, it is incumbent upon this report to draw the local demographic and economic trends.

As mentioned before, the District of Wirral, despite an indisputable geographical closeness to the Liverpool Urban Area, is not considered as a member of this urban area. The River Mersey flow between these domains creates two distinct geographical spaces with their proper economic and socio-demographic statistics (Map 3).

**Map 3: The Wirral territory and the neighbouring city of Liverpool**



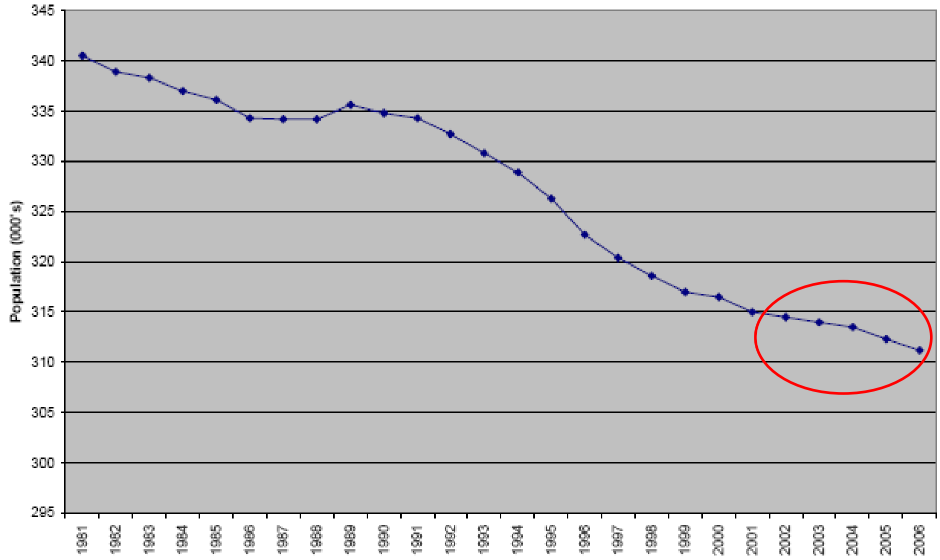

*Source: http://maps.live.com*

Wirral population bore a fast slump over the end of the 20th century, in the same proportions as the whole Merseyside county but like Merseyside, the drop seems now slowing and leveling off with apparent signs of improvements (Figure 4). The descending population slope is indeed more smooth in the recent years than in the 90's, and even if the last two years' disappointing ONS figures have thwarted hopes

[4] Office of National Statistics, 2004

of a short-term progression, a more populated future is still expected on a longer time period.

**Figure 4: Wirral population, 1981-2006**




*Source: Office of National Statistics (2007)*

With its current 311,200 inhabitants, Wirral represents 23% of Merseyside population. When compared with the other boroughs of the county, the Birkenhead district, despite the regular persons outflows, yet appears as the second most inhabited of Merseyside after Liverpool and its 2005-2006 decrease rate is actually situated in the middle range of the global county's values (Table 1).

**Table 1: Population - Merseyside district's comparison, 2005-2006**

| Year | Wirral | Merseyside | Liverpool | Sefton | St Helens | Knowsley |
|---|---|---|---|---|---|---|
| 2005 | 312,000 | 1,367,400 | 447,500 | 280,900 | 176,200 | 149,400 |
| 2006 | 311,000 | 1,353,600 | 436,100 | 277,500 | 177,600 | 151,300 |
| % change 2005-2006 | -0.4% | -1.2% | -2.6% | -1.26% | 0.79% | 1.26% |

*Source: Office of National Statistics (2007)*

Concerning local output, Wirral's GVA per head reached £9,891 in 2004, 58% of the UK's one. With this statistic the borough appears the less productive in Merseyside, all the more since it showed the lower rate of growth between 2003 and 2004 with 4.7% (Table 2). But it is to remind that GVA figures are workplace based rather than residence based: if Wirral has significant out-commuting, which is likely to happen regarding the noteworthy amount of employment opportunities within and around Merseyside, the economic wealth generated by these residents who work in other boroughs is captured there, rather than in their home location.

**Table 2: GVA per head - Merseyside district's comparison**

| | Growth 2003-2004 | Value 2004 | Indexed to UK |
|---|---|---|---|
| **Liverpool** | 5.7% | £15,530 | 91 |
| **East Merseyside (Knowsley & St Helens)** | 5.5% | £11,676 | 68 |
| **Sefton** | 5.6% | £11,321 | 66 |
| **Wirral** | 4.7% | £9,891 | 58 |
| **Merseyside** | 5.5% | £12,448 | 73 |
| **Northwest** | 5.4% | £14,994 | 88 |

*Source: Office of National Statistics (2007)*

The number of economically active people in Wirral, *i.e.* the total of persons aged 16 and over who are either in employment or unemployed, progressed by over 8,000 from 1999 to 2005 (however nearly 6,000 were lost between 2004 and 2006). Wirral maintained constantly a greater percentage of the number of economically active people compared to the Merseyside average over this period (Table 3).

**Table 3: Economically active people in Wirral, March 99-December 2006**

| Period | Wirral | Wirral (%) | Merseyside | Merseyside (%) |
|---|---|---|---|---|
| Mar 99 - Feb 00 | 132,000 | 71.4 | 560,000 | 69.6 |
| Mar 00 - Feb01 | 138,000 | 74.6 | 572,000 | 79.6 |
| Mar 01 - Feb 02 | 140,000 | 75.2 | 575,000 | 70.9 |
| Mar 02 - Feb 03 | 137,000 | 73.9 | 578,000 | 71.2 |
| Mar 03 - Feb 04 | 145,600 | 77.3 | 585,000 | 72.0 |
| Jan 04 - Dec 04 | 146,100 | 77.3 | 589,000 | 72.7 |
| Jan 05 - Dec 05 | 144,800 | 76.2 | 592,300 | 73.1 |
| Jan 06 - Dec 06 | 140,300 | 73.9 | 607,600 | 73.4 |

*Source: Office of National Statistics (2007)*

With an employment rate of 71.7% among the working age persons, Wirral is the second most active borough in the county after St Helens, and is situated higher than Merseyside's 68.2%. Its unemployment rate was at 3.8% at the end of 2006, it has known a substantial 0.6% rise between 2005 and 2006 which prevents it from reaching the most effective districts in this domain now (Table 4).

**Table 4: Unemployment rates - Merseyside district's comparison**

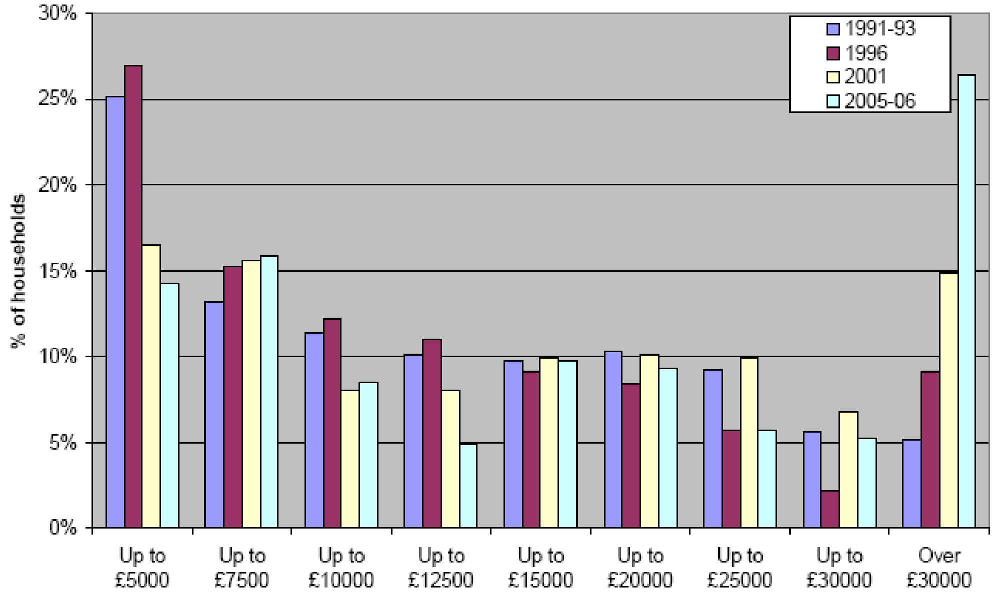
| | December 2006 | | Change since last year | |
|---|---|---|---|---|
| | Number | Rate | Number | Rate |
| **Merseyside** | 37,701 | 4.1 | 3,058 | 0.3 |
| **Knowsley** | 3,989 | 4.4 | 185 | 0.2 |
| **Liverpool** | 16,053 | 5.5 | 1,044 | 0.4 |
| **Sefton** | 4,983 | 3.0 | 444 | 0.2 |
| **St Helens** | 3,117 | 2.9 | 187 | 0.2 |
| **Wirral** | 7,053 | 3.8 | 1,083 | 0.6 |

*Source: Office of National Statistics (2007)*

Nonetheless, as far as the earnings are concerned, Wirral still shows the highest median level of gross weekly earnings in Merseyside at £362, a 2.5% enhancement between 2005 and 2006 (while Liverpool knew the fastest growth in the county regarding this figure with a 6.9% surge over this period). A newsworthy observation is that whereas Wirral has a higher income than the Merseyside by residence, it doesn't by workplace. This may reflect that Wirral has residents who commute to outside districts for employment and for higher income employment.

The next figure (Figure 5) illustrates the household income distribution amongst people living in the borough, and its evolution within the past 15 years. It evidences that the part of highest revenue households (over £30,000 a year) has skyrocketed since 1991, up to more than a quarter at the end of 2006 against a 5% in the early 90's. On the contrary, the lowest income part (up to £5,000 a year) has consequently decreased to less than 15% in 2006, while the middle range revenues have been more randomly changed during this time interval.

**Figure 5: Household income in Wirral**




*Source: Wirral Countywide Travel Survey (2005-06)*

Birkenhead, Wirral's most populated town, is the major gathering place of residences, employments and shops in the borough. From the last official counts (ONS Census 2001), it encompassed 83,729 dwellers but its population total is likely to be a few less now when considering the structural emigration both endured by Wirral and Merseyside. The city borders are located on the Wirral Peninsula along the west bank of the River Mersey, only 3 km (1.9 miles) on the opposite side from the centre of Liverpool. Birkenhead forms, within the contiguous built-up area linking neighbouring towns along the eastern side of Wirral, the Birkenhead Urban Area as defined by the ONS. This sector includes important cities like Wallasey (58,700 inhabitants), Prenton (14,400 inhabitants), Bebington (13,700 inhabitants), Rock Ferry (13,700 inhabitants), the outer-Wirral Ellesmere Port (64,100 inhabitants) and many other Wirral towns making the total population of the perimeter hit 319,675 persons from the ONS 2001 Census. In Merseyside no other conurbation, apart from the Liverpool Urban Area, is larger than the Birkenhead one which was even ranked 22nd in the UK largest conglomerations according to the 2001 Census.

Facilitated by its geographical position, the city of Birkenhead is famous as a centre node for ship building and as a seaport. It has received a successful heritage from the last decades' strong port-related industries and today's Wirral docks, established at a short distance from the town center, result from a deep modernization that has allowed the city to create international links with other harbour-cities. In the meantime Birkenhead, as well as other members of the urban area, diversified its industrial structure to make the local economy fit to the continually changing world, thus its activity nowadays include pharmaceuticals, engineering, chemical, food, and allied trades and soap manufacturing industries. Wirral authorities are then at present enraptured to point out new enterprises are flourishing and businesses are prospering in this "peninsula of opportunity".

This depiction of the Birkenhead area and its surrounding environment, an economically healthy place managed by local authorities greedy for attracting firms, people, employments, and making growth surge even better, lead to think persons exchanges may be significant between Wirral's largest city, its neighbouring Liverpool Urban Area, and obviously other domains inside Merseyside and the UK. This will be gone into thoroughly in the second part of this report, which will predominantly focus on the local mobility behaviours and the provided transport systems that are supposed to match up to the mobility demand.

*Synthesis:*

- Merseyside, an administrative and territorial division of the UK which transferred most of its functions to its five metropolitan boroughs.

- A demography in the heart of a structural slump in the county, even though hopes of a regeneration light up Wirral and the other district's future.
- An evidenced economical attractiveness, mirroring steady output growth, low-maintained unemployment rate, and high employment rates
- Birkenhead, core of a large urban area stretched over an extensive territorial space, facing Merseyside's main conurbation of Liverpool, and major mover of Wirral's economy.

# Part 2. Transport systems and travelling behaviours across the Birkenhead area

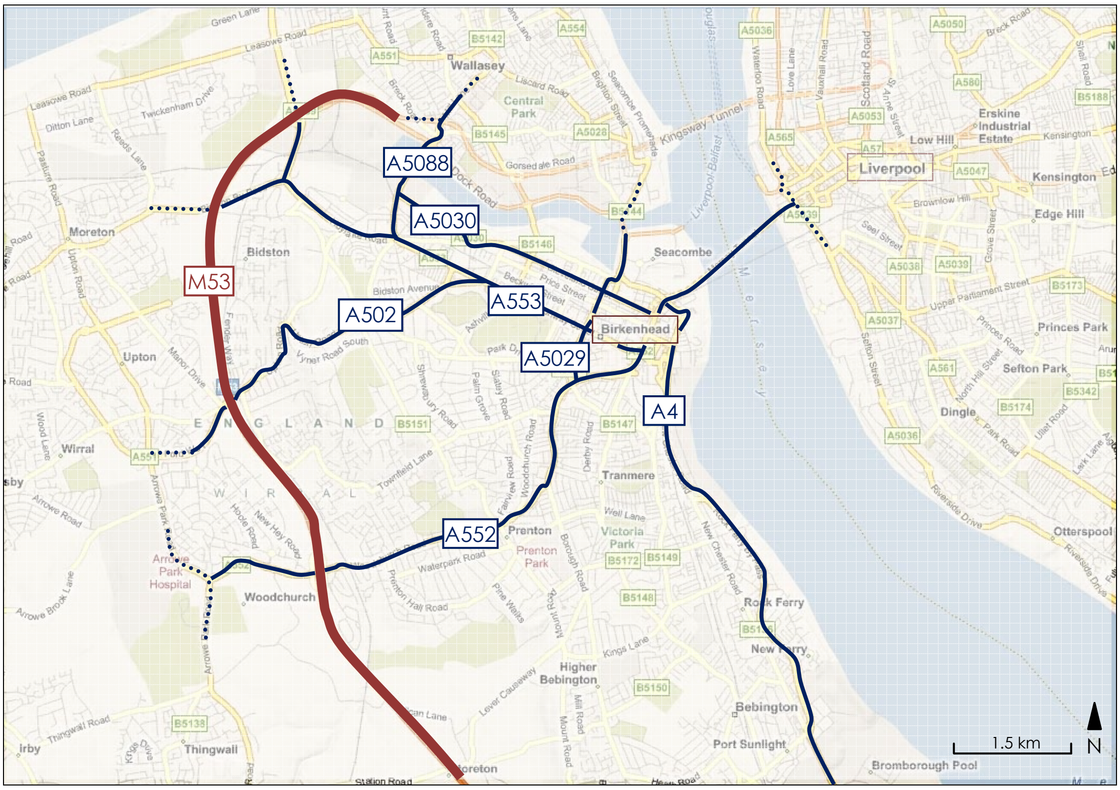
This chapter will allow knowing more about how the sundry means of transport inside and around Birkenhead are shared across the territory, and how they are used. It will also point the difficulties related to road congestion which have led authorities to seek for measures supposed to enhance the transport system's reliability.

## *2.1. Transport infrastructures and services*

Before seeking to understand people's travelling habits, a preliminary definition of all transport possibilities supplied to the population around the studied place appears essential. As far as Birkenhead and its surrounding sector are concerned, many options appear to be offered as part of the local trips: road infrastructures with more or less large capacities, motorways, public transport services (buses, underground trains, and ferries) within Birkenhead borders on the one hand, and between the city and its proximity on the other hand, and lastly walk and cycle.

The following Figure 6 illustrates the main road network passing through Birkenhead and linking the city to the closest Wirral and Mersyside territories.

**Figure 6: Main road network within and around Birkenhead**




Source: http://maps.live.com

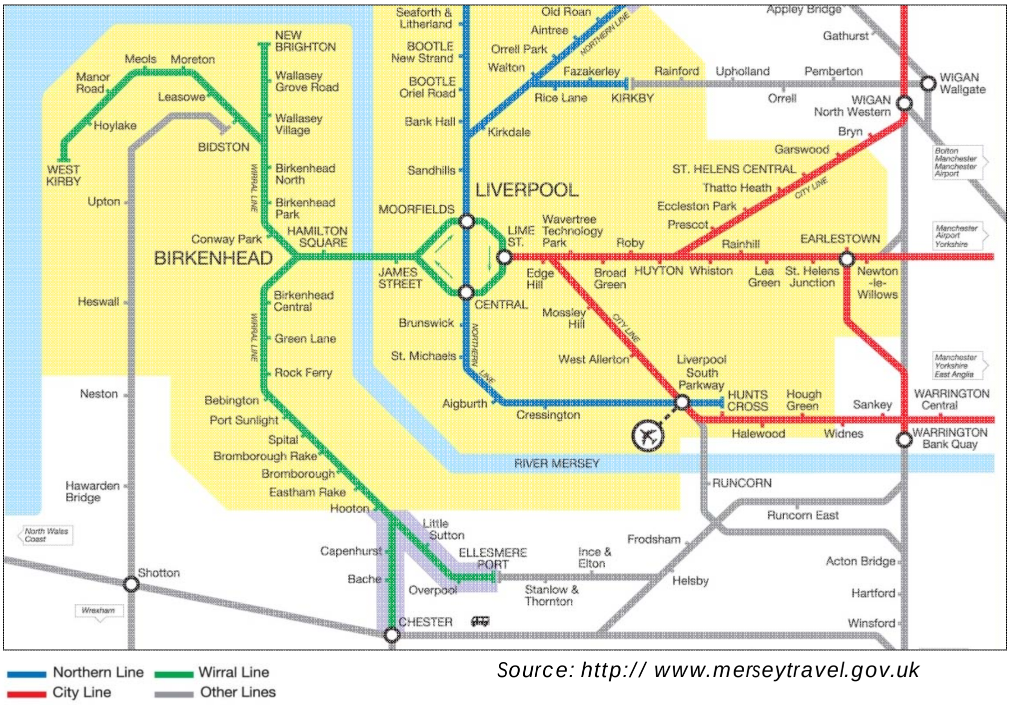
The main infrastructure regarding traffic capacity is the M53 motorway, which crosses Wirral from the north to the south and provides with high speed travel options to the Birkenhead Urban Area cities along the peninsula. This equipment starts its route from Wallasey's bounds in the northern urban area's extremity, over the exit slip roads of the Liverpool Kingsway Tunnel, then passes round the west of Birkenhead offering diverse approaches to the town and its suburbs, and finally passes Wirral borders to hit the Chester motorway network (providing accesses to the Cheshire County and the north Wales).

The M53, which allows Birkenhead and Wirral to be effectively connected to the most populated places of Merseyside and UK, is relieved locally by several A-roads (*i.e.* most strategic non-motorway infrastructures by UK's nomenclature) that provide sharper access to the cities of the territory. Hence Birkenhead benefits from many A-roads joining the town centre to the motorway or to other cities of the urban area, among which the A552, subject of this study, is part. These equipments are themselves relieved by roads from another sub-category, the B-roads (less strategic and even more local than the A category), and both A and B-roads possess variable capacities depending on their locations in the network.

As far as sustainable transport means are concerned, the area appears at first sight to get a mass-supply in a quantitative point of view. Bus lines typify the major public transport option within the framework of trips around the Birkenhead Urban Area, with 108 different services (to qualify though, as several services actually use identical routes but are distinguished because they are operated by different private companies or run over different time periods) covering a consequent part of the territory on each of the sector's main roads, providing accesses to the important local generators and also standing for a strategic way to narrow down geographical inequalities between people's residential locations (as well as income differences, when reckoning all dwellers can't afford travelling by car). Some of the bus services are only urban, namely internal in Birkenhead, when others are interurban and allow to travel from the central city to the neighbouring towns. The routes which come under the scope of this study (*i.e.* those running on the A552) will be depicted precisely in the following chapter of the document.

Birkenhead and Wirral are besides equipped with the Merseyrail system, an underground commuter train network centred on Liverpool which serves the major cities of Merseyside and even outside the county (Figure 7). Situated on the Wirral line, Birkenhead embraces six Merseyrail stations within its borders, of which one (Birkenhead Central) is located at the eastern extremity of the A552 when the others are scattered on a north/south direction to cross the urban area's cities along the Wirral peninsula.

**Figure 7: The Merseyrail network within and around Birkenhead**




*Source: http:// www.merseytravel.gov.uk*

Birkenhead's particular geographical situation allows moreover its inhabitants and visitors to travel by ferry on the River Mersey. The service, called Mersey Ferries River Explorer Cruise, provides journeys from Seacombe at the very eastern tip of Wirral (closed to the Birkenhead town centre) to join Liverpool banks within ten minutes, and runs early mornings and evenings seven days a week. It stands for an option, in the midst of the customary transport means, for work and leisure-related trips between the Wirral peninsula and Liverpool.

And finally, the usual "environmentally-friendly" modes (walk, cycle) obviously stand for relevant transport possibilities in the area. Yet, if walkways are frequently set up along city streets, cycle path seem to be much less conspicuous in the road landscape: apart from short spaces marked on the ground in front of several traffic lights, supposed to keep cars and bikes fairly distant on junctions edges, there are actually no path especially dedicated to cyclists in Birkenhead and its outskirts. Bike-users are nevertheless permitted to use bus lanes but safety appears more uncertain in this situation, and ultimately cycle looks like the less facilitated transport means among all sustainable modes across the Birkenhead Urban Area.

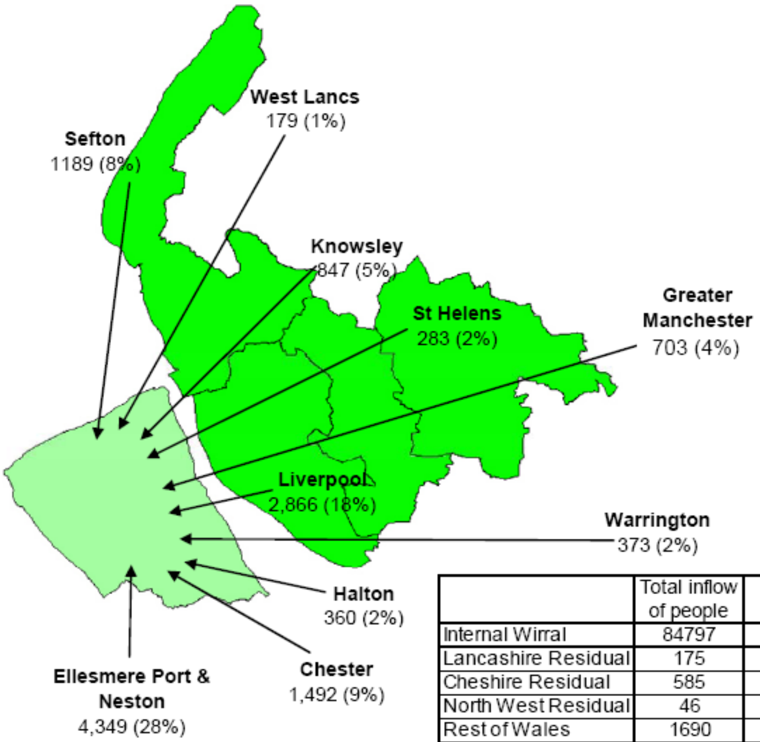
## *2.2. Heavy transport demand and domination of the car*

The whole of transport possibilities being now presented, it is to appreciate how people use these infrastructures and services in their everyday life. In that purpose several data will be mobilized and tallied with each other, by minding the fact they have been created by different entities with their own methodologies, and at different times. Many of them concern the entire Wirral district territory but as pointed out before, Birkenhead and the Birkenhead Urban Area constitute an overwhelming part of Wirral both in terms of population and economic activity. The information related to the whole Wirral can then be easily considered as pertinent for the scope of this study which focuses on the city of Birkenhead.

Hence the Wirral Countywide Travel Survey, conducted at three to four year intervals since 1987/1988, provides with handy results about people's travel habits on a typical weekday. It includes all trips (*i.e.* movements accomplished from a specific origin to a specific destination, between a given departure time and a given arrival time, and whatever the number of different transport means used) made by people aged more than five inside the borough. The latest achievement of this survey, carried out in 2005/2006, firstly evidences that the most common daily number of individual trips made in Wirral is two (Appendix 1, page 106): 50% of the persons encompassed in the survey sample travel two times a day, an average that has always been the typical figure from 20 years and that is increasingly over-represented, when 17% move four times, 9% move three times, and less than 2% move only one time. The part of individuals who claim they don't travel has been in regular decrease from the first survey, falling from 13% in 1987/1988 to only 8% in 2005/2006. These consequent travel rates are not surprising when observing the comparison of household incomes and number of daily trips among people of the Merseyside counties (Appendix 2, page 106): the more households earn, the more they get around, and as Wirral has the highest average earnings level within the county, its dwellers were actually expected to move substantially.

The Wirral Countywide Travel Survey shows moreover that the predominant purposes of Wirral trips in 2005/2006 (Appendix 3, page 107) are shopping (22%), work (20%), and leisure activities places (17%) from home, these travel origins and destinations being constantly over-represented in the trip possibilities midst. As far as work trips are concerned in particular, origins and destinations of outflows and inflows from and to Wirral can be knows thanks to the ONS national census, achieved once every ten years, which captures details of all persons' travel to work and thus brings highly valuable travel data. The latest census in 2001 allowed first to know 84% of the inflow in direction of Wirral is internal: only 16% come then from outside, which may mirror the Birkenhead borough's lack of job opportunities and places able to generate a consequent number of work trips from diverse origins, and shows a relative deficit of attractiveness compared to other boroughs like Liverpool. The external inflow is mainly originated from Wirral's closest areas (Figure 8): Ellesmere Port and Neston represent 28% of this remaining percentage (4.5% of overall total), when Liverpool produces 18% (2.9% of total), the neighbouring Wales 11% (1.4%), Chester 8% (1.3%) and the remainder is scattered in other further locations.

**Figure 8: Wirral as a destination for travelling to work, 2001**

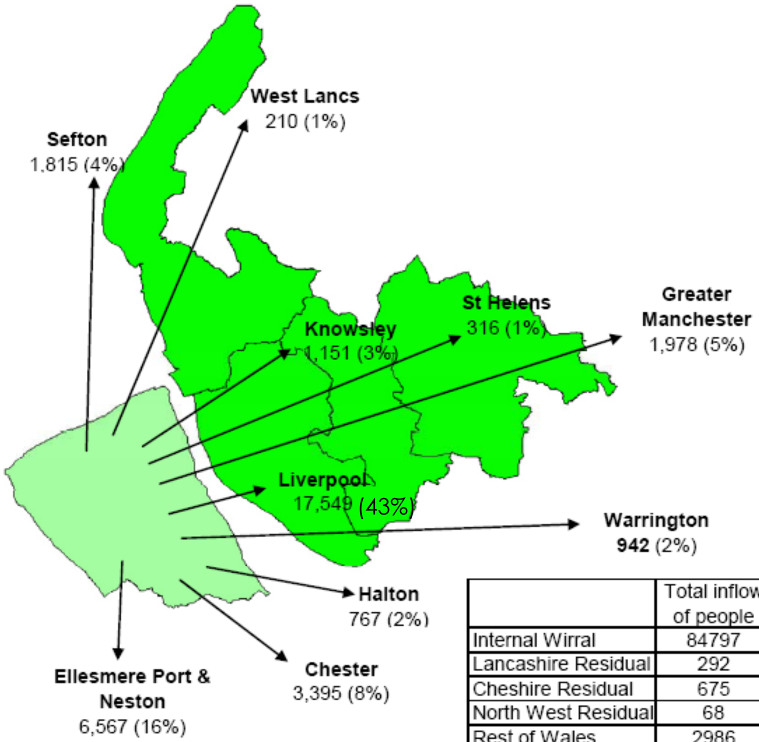



| | Total inflow of people | Percentage of inflow |
|---|---|---|
| Internal Wirral | 84797 | 84% |
| Lancashire Residual | 175 | 1% |
| Cheshire Residual | 585 | 4% |
| North West Residual | 46 | 0% |
| Rest of Wales | 1690 | 11% |
| Rest of England | 640 | 4% |

*Source: ONS Census 2001*

As expected, much more work journeys are undertaken by Wirral inhabitants into places located outside the Birkenhead district: among the outflow total from Wirral, only 68% are internal and remains inside the district when nearly one third are leaving the local perimeter. The favourite outside-Wirral work destination (Figure 9) is by far Liverpool with 43% of non-internal journeys (13.8% of overall total), followed by Ellesmere Port and Neston with 16% (5.12%), Chester with 8% (2.56%), and other less important sectors. It is to point out that the Greater Manchester, more distant from Birkenhead and Wirral than all Merseyside districts, attracts more work trips than each of these districts apart from Liverpool.

**Figure 9: Wirral as an origin for travelling to work, 2001**




| | Total inflow of people | Percentage of inflow |
|---|---|---|
| Internal Wirral | 84797 | 68% |
| Lancashire Residual | 292 | 1% |
| Cheshire Residual | 675 | 2% |
| North West Residual | 68 | 0% |
| Rest of Wales | 2986 | 7% |
| Rest of England | 2117 | 5% |

*Source: ONS Census 2001*

Concerning travelled distances in particular, statistics allow to witness work trips distances were increasingly long between 1991 and 2001 (Table 5), with a doubled proportion of 10 km-to-30 km (16.1 miles to 48.3 miles) journeys between these two dates (which corresponds to a shift from one tenth of the trips to one fifth), a tripled part of over-30 km (48.3 miles) journeys, whereas shorter trips fell significantly as the less-than-2 km (3.2 miles) tilted from 30% to 19% and the 2 km-to-10 km (3.2 miles to 16.1 miles) from 58% to 54%. These longer trips may eventually mirror effective updating of the transport infrastructures and services between the 90's and the early-21st century, as it is often observed that the faster trips are globally made (thanks to the infrastructures and services improvements), the more important travelled distances are. This conversion from higher speeds into longer distances could then be applying in the Wirral case, even if no specific study has been achieved to confirm this statement.

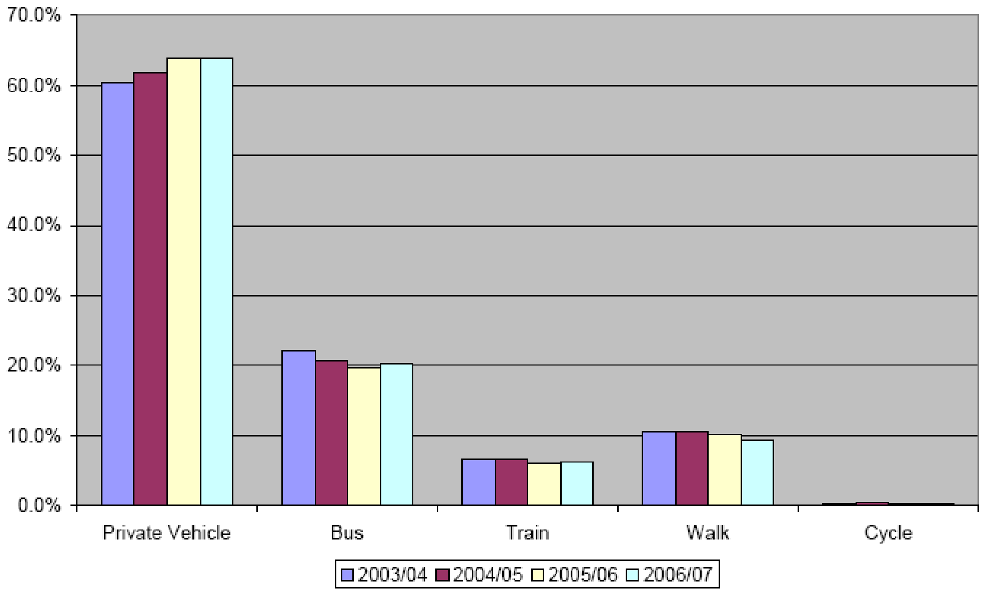
**Table 5: Wirral distance travelled to work by workplace, 1991/2001 comparison**

| Year | Less than 2 km (1.2 miles) | 2 km - 10 km (1.2 - 6.2 miles) | 10 km - 30 km (6.2 - 18.6 miles) | Over 30 km (18.6 miles) |
|---|---|---|---|---|
| 1991 | 30% | 58% | 11% | 2% |
| 2001 | 19% | 54% | 21% | 6% |

*Source: ONS Census 1991 and 2001*

As for the modal share, the diverse available data evidence an irresistible progression of the car amongst Wirral trips over the last years and decades, and a linear decrease of well-nigh all sustainable modes use (bus, walk, cycle). The Wirral Countywide Travel Survey shows this trend peculiarly for the whole borough (Appendix 4, page 107), with a car modal part (drivers and passengers included) that skyrocketed from 48% in 1987-1988 to 65% in 2005-2006, whereas bus-services use fell from 15% to 9% between this two decades. In the same time, walk trips tumbled to only 22% in 2005-2006 when they were 30% twenty years ago, and bike journeys were even more marginalized than they had been before. Finally, train is the only sustainable transport mean whose part was leveled off between the first and the last survey, but it still stands for less than 3% of the total Wirral trips. When considering transport modes split inside the borders of Birkenhead, whose figures can be observed with the help of the Annual Cordon Survey (commissioned by the Merseyside Local Transport Plan Coordination Group on an annual basis) which counts flows entering the town centre during an AM peak period (namely 07:30 to 09:30) on a typical weekday, the evolution is nearly the same (Figure 10): the percentage of private vehicles drew near to two third in 2006-2007 after a slight but regular increase from 2003/2004, and the part of buses fell by 2% to one fifth of the city trips (a percentage by far higher than for the whole Wirral anyway). In the meantime walk trips remained at a very low level (around 10% only), bike trips became well-nigh totally absent (which is not very surprising due to the lack of cycle tracks that has been mentioned before), and trains patronage kept a 6% part thanks to the underground services.

**Figure 10: Birkenhead town centre modal share (AM peak period)**




*Source: Annual Cordon Survey (2007)*

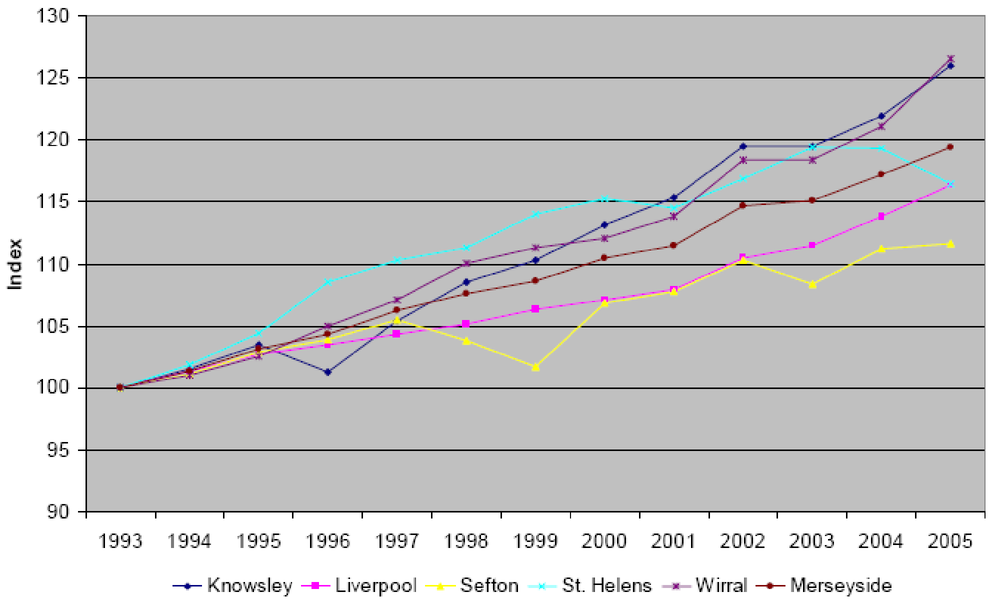
This increasing car plebiscite is reflecting Wirral's high level of car ownership: even if Merseyside has an historically lower level than many of the other UK areas, Wirral households have a more important car ownership rate than in the four other boroughs of the county. The Birkenhead borough's 70% average of households possessing at least one vehicle or more is fairly similar to the North West region one (Appendix 5, page 108). Likewise, Wirral's motorization rate figure shows, in time, a growing part of households owns two, three or more vehicles when a lowered part possesses zero or one (Appendix 6, page 108).

When reminding the transport network includes roads (motorway, A and B-roads) which have variable absorption capacities, this high transport demand, and especially this high car-based transport demand, is likely to represent strong threats to the whole transport system reliability, what the next section of this chapter is going to confirm.

## *2.3. Road transport system limitations*

The Birkenhead Urban Area and the Metropolitan Borough of Wirral are experiencing increasingly high trip requirements in contexts of upward car ownership, car use and travelled distances, and downward sustainable mass-transport modes use. The first consequence is not surprising and is observed along the main road network: traffic is growing steadily. The figure reputed the most robust to evidence this trend has been carried out by the DfT, whose estimated traffic flows for the 1993-2005 period (Figure 11) show transport infrastructures have inescapably known a regular surge of their visiting in all Merseyside districts. Wirral appears to have endured the highest growth rate compared to the other areas, with a more than 25% traffic rise from 1993 to 2005 whereas Merseyside's rate is under 20% over this period.

**Figure 11: Estimated traffic flows by district for all motor vehicles, 1993-2005**

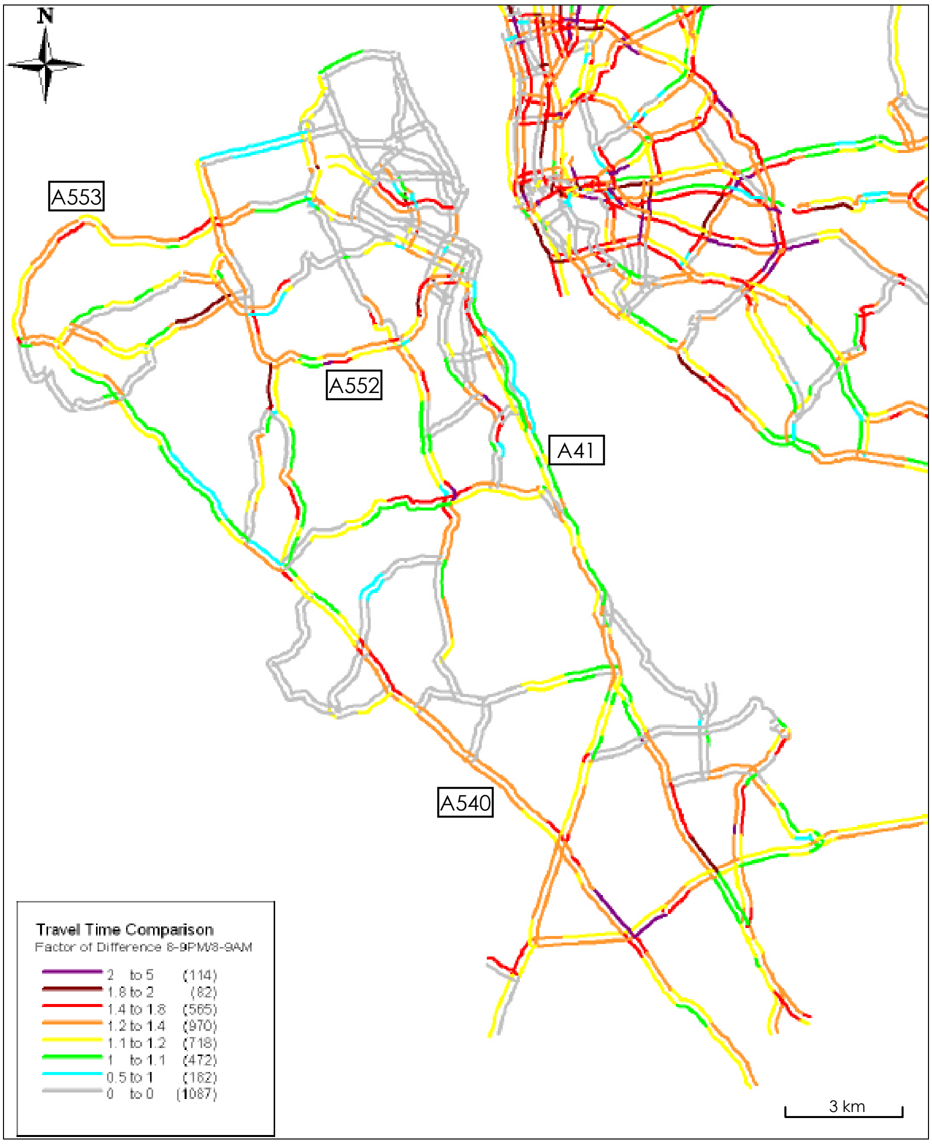



*Source: Department for Transport (2006)*

Flows are expected to grow even higher in Wirral in the next two decades, according to DfT's TEMPRO factors based on the year 2006 (Appendix 7, page 109) that evidence the borough could bear a new 15% increase by 2021 compared to 2006.

Therefore this increasing traffic is closely correlated to the second consequence of the previous observations: congestion is getting more and more problematic across the urban area network and its neighbouring sectors. This can be easily noticed thanks to ITIS Holdings consultancy data (Figure 12), which uses satellite vehicle tracking information to show the factors of difference between free flow traffic conditions (i.*e.* traffic performances in perfect circulating conditions, namely during an off-peak period taken here as 8:00 PM - 9:00 PM), and the morning peak hour (taken as weekday 8:00 AM - 9:00 AM time interval). If Liverpool appears the most penalized by congestion (and particularly on the A and B-roads that lead to the city centre), with factors of differences often above 1.4 between free flow and peak hour traffic conditions, the Birkenhead area doesn't show encouraging performances: nearly all the main A-roads joining Birkenhead to the rest of the peninsula present factors of differences comprised between 0.5 and 1.8, like the A41 on the eastern side of the peninsula, the A552 in the middle of the territory, the A553 on the north, or the A540 on the western side. One of the most congested urban infrastructure is the A552, logically chosen as the corridor which will be tested within the scope of the traffic monitoring for the Birkenhead case in this project. The A552 stands indeed for a very representative road regarding traffic difficulties that are supposed to be fought as part of the Merseyside LTP.

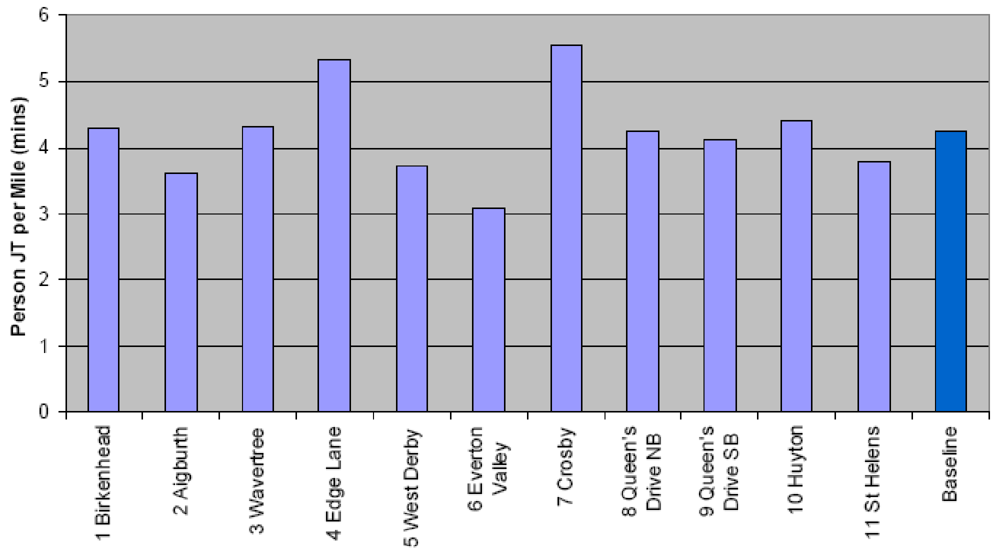
**Figure 12: ITIS congestion points in Wirral, 2005**




*Source: ITIS tracking data (2008)*

When looking at journey times on the eleven select routes of the Merseyside LTP (Figure 13), it is noteworthy to see the Birkenhead A552 corridor easily reaches the five most congested infrastructures regarding journey times per mile achieved. Collected by the Mott MacDonald Merseyside Information Service (MIS), these data are obtained by recording travel times for all vehicles on several strategic points of the routes (Appendix 8, page 109, illustrates the Birkenhead corridor recording), and evidence an average of more than 4 min is necessary to accomplish one mile on the Birkenhead route (slightly above the baseline average) , when 5 minutes 30 sec are necessary on the panel's worst infrastructure in Crosby, and 3 min on Everton Valley which is the best route among the eleven study cases.

**Figure 13: Merseyside congestion indicators, corridors baseline data**




*Source: Mott MacDonald Merseyside Information Service (MIS)*

Wirral surveys show that if inhabitants don't systematically consider congestion as a real problem every day (Appendix 9, page 110), above all on the routes outside the city centres, they massively think traffic conditions became globally worse over the recent years (Appendix 10, page 110) and a very marginal proportion claims it got better.

Finally, Appendices 11 and 12 (page 111) evidence other concerns regarding the whole Wirral road transport system performances which, if they are not exclusively attributable to congestion, are inescapably partly affected by it: Appendix 11 shows pollution concentrations for Nitrogen Dioxide from all sources, although transport (and obviously clogging) is a significant contributor for these pollutants. The impact of transport on pollution can be clearly seen along the M53 and A41 corridors and the Birkenhead town centre (industrial uses on the eastern side of the borough create as for them, the non-transport pollution that is clearly shown on the map). Appendix 12 illustrates the killed or seriously injured (KSI) people along the Wirral road infrastructures (which are obviously not systematically originated in congestion, but it is acknowledged that potential traffic jams generally stand for further threats on road safety). The figure proves authorities have been bearing difficulties to fight against road safety uncertainties from the past fifteen years, with KSI figures constantly wobbling between 150 and 200 persons per year when the target is to reach only 100 in 2010.

The trends pertaining to travel behaviours in the Birkenhead Urban Area on the one hand and more globally in Wirral on the other hand, and the arising congestion issues brought up so far don't allow to expect an optimistic future for the road transport reliability if nothing is done, and may lead to harmful consequences regarding regional competitiveness, quality of life and environment that would evidently not be desired in the context of anticipated economic growth and prosperity for the area. Better still, sustainable modes' global decline in the sector, led by the buses patronage slump, does not fit the usual targets of less car-aimed trips authorities generally wish to fulfill in UK and around the world. But in the Wirral case, bus customers' downward loyalty has to be compared to the performances bus services provide: as part of saturated traffic conditions, road public transport performances can only be poor if no effort is undertaken to bring them acceptable for usual and potential sustainable transport patronage.

That is within the framework of this multi-stakes context the local LTP is playing a crucial role: the testing which will be carried out on the Birkenhead A552 corridor, one of Wirral's most jammed urban route, must permit to find out pertinent solutions to Wirral clogging problems and consider the road traffic with much more enthusiasm for the next years. In that purpose the latest microsimulation tool, VISSIM 5.0, will be used by modelling the entire A552 corridor before proceeding, afterward, to the testing. The next part of this document will then meticulously depict the different modelling steps, by minding the usual limitations of such a methodology

*Synthesis:*

- A dense road network organized around the M53 motorway and the A and B-roads.
- An seemingly increasing transport demand for twenty years, led by an upward attraction for car, and strongly linked to Liverpool especially for the outflows from Wirral.
- Regular traffic and congestion growths on the main road infrastructures, notably on the A-roads, and a still expected increase for the next decades.
- A transport reliability, a local economic competitiveness, a quality of life and environment, and a public transport patronage that are threatening to deteriorate even more in the future if no action is undertaken.
- The A552, one of Wirral's most jammed route, which stands for a representative infrastructure in the borough regarding traffic issues, and on which this study will focus exclusively within the scope of the microsimulation model building.

# Part 3. Modelling the network with the microsimulation package

Once it will have allowed to be acquainted with VISSIM, the microsimulation software through which subsequent testing will be achieved regarding congestion monitoring, this chapter will be describing all the modelling process that is supposed to reproduce the A552 corridor as realistically as possible. This building contains several limitations, that will be rigorously pointed out at the end of this section.

As revealed previously, the A552 appears to be one of the most saturated road infrastructure within the Wirral territory and is representative of the jam problems bore by the borough. It is therefore expected to be very appropriate as part of this project and may allow to deliver pertinent results.

## *3.1. VISSIM: a robust microsimulation tool*

Existing software resources to model the proposed improvements have been investigated. For the scope and level of detail of this study, which is fairly high, a microsimulation modelling package was recommended. Then Mott MacDonald has carried out research of the market place and concluded the VISSIM microsimulation package is the one that provides the best balance between simulation sophistication, user control, and graphical output. One of the latest version of the software, VISSIM 5.0 (the last release before the recent VISSIM 5.1 updating), will be used for this project.

VISSIM is a sophisticated mathematical model which allows for an individual and disaggregate traffic reproduction, with a strong visual interface. Its assignment model provides with the possibility of replicating users route choices on the network. The software possesses an inbuilt flexible motorist, pedestrian and cyclist's "behaviour algorithm" whose variables can be altered to match up local conditions and achieve testing wherever the place of the study. It is able to replicate advanced signal timings on controlled junctions, not only for motorized road users but also for pedestrians thanks to pedestrian demand programs. A VISSIM model can hence be used, among other things, to survey the impact of policies on pedestrians and their responses to the environment.

The software is also a robust dynamic traffic assignment tool, that can model route choices of all road users (motorists, heavy goods vehicles and light goods vehicles drivers, cyclists, motorcyclists, pedestrians), set up users responses to intelligent route guidance systems (speed limitations, variable parking places,…) and reproduce parking choices explicitly. Moreover, VISSIM is able to model precisely the operations of public transport, such as scheduled based arrivals, loading and unloading of passengers, dwell times, and the relations between passenger demand and operation of trams, buses, rail and taxis. And finally, all VISSIM models can be converted into three-dimensional animations which are relevant for presentation purposes, especially for secular users.

The key benefits of using a VISSIM microsimulation strategy are the possibility to take into account, with large adjustment possibilities, traffic composition, priority rules, driving attitudes, traffic lights positions, pedestrian crossings, bus routes, stop locations, junction delays, queue lengths, and many other inescapable components of usual traffic conditions. Specific detailed operations of public transport such as bus priority rules can be easily modelled, which will prove to be useful in the context of this project, but VISSIM can also examine wider effects of transport policies on the whole of the users, and even on the society: the models can indeed be used to evaluate benefits and costs to all users of the system in a integrated way and the outputs can be linked to economic and environmental impact of the schemes.

Therefore the VISSIM microsimulation model of the A552 corridor congestion monitoring will allow for the most detailed study regarding the impact of design interventions on the network and on its various users. As all transport modes (cars, buses, heavy and light goods vehicles, cycles, motorcycles and pedestrians) need to be included in the model within the scope of a congestion monitoring study such as this project, as they are central to the traffic operations in any clogged infrastructure. The interdependency between all these modes will be taken into account, the impact of a particular user class on the others' performances being measurable in an integrated way.

All these benefits expounded so far, which establish the VISSIM package as the most suitable tool for this study, are expected to offset the consequent investment required to collect the necessary data and to build the model in its entirety, whose long process is described in the next section.

## *3.2. The model building process*

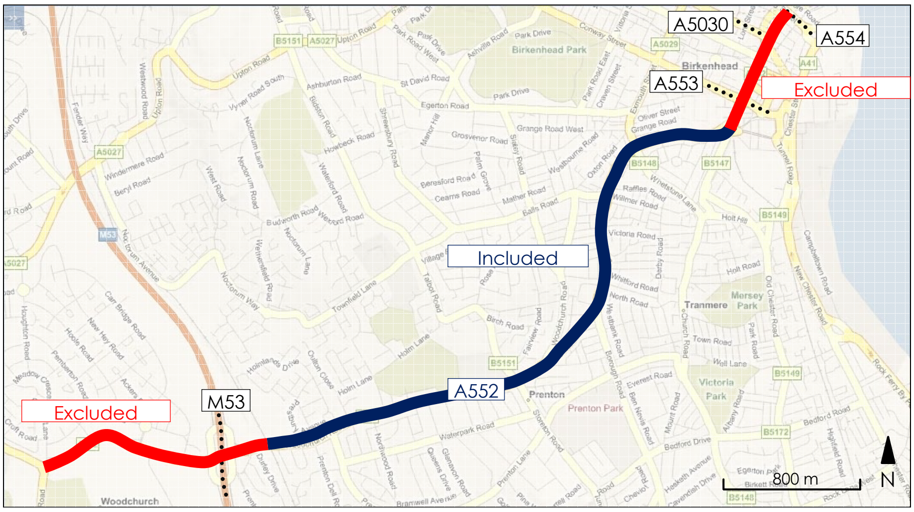
The model building stage is a meticulous process, which requires time and rigour as it affects crucially the whole output results and evidently the analyses following from these results. Due to the importance of this project, it is mandatory to exclude any error that may hinder the improvement testing, and it is strongly recommended to justify clearly each of the assumptions which are used through the progress.

The following steps will hence we depicted in this section of the chapter, pointed out in the chronological order they are operated according to this project's strategy: spatial delimitation of the network's section to model and selection of the simulation time period, roads and roads connectors reproduction, nodes and turns shaping, definition of the traffic composition, desired speed distributions, reduced speed areas coding, priority rules coding, traffic signals coding, public transport lines coding, specification of the traffic production and attraction points, and finally data collection points localization.

### 3.2.1. Spatial delimitation of the network's section to model, and selection of the simulation time period

Prior to the first steps of the A552's virtual building in VISSIM, it is required to mark off with precision the exact perimeter of the corridor that will be embraced in the model. As portrayed before, the A552 route starts from the Birkenhead city centre, on the eastern side of the peninsula, and joins the M53 motorway in the middle of the territory. The infrastructure actually ends in the town of Woodchurch, which is laid over the western side of the M53 very closed to Birkenhead, and the total length of the A-road is approximately 6.7 km (4.2 miles). But in the context of the study, this very western section of the equipment, as well as its very eastern part which communicates with the A553, A554 and A5030 will not be modelled (Figure 14) as they are not concerned by congestion, contrary to the central part: the VISSIM-modelled route will therefore start from the exit of the Argyle Street/Borough Road roundabout junction in the east, and end just before the Woodchurch Road/M53 roundabout junction in the west. It will be finally 4.2 km (2.7 miles) long and its eastern extremity will include all trips coming from or going to the Birkenhead city centre or Liverpool (as it leads directly to the Mersey Tunnel) when the eastern extremity will encompass all connections with the M53, Woodchurch and other cities located in the west of Birkenhead.

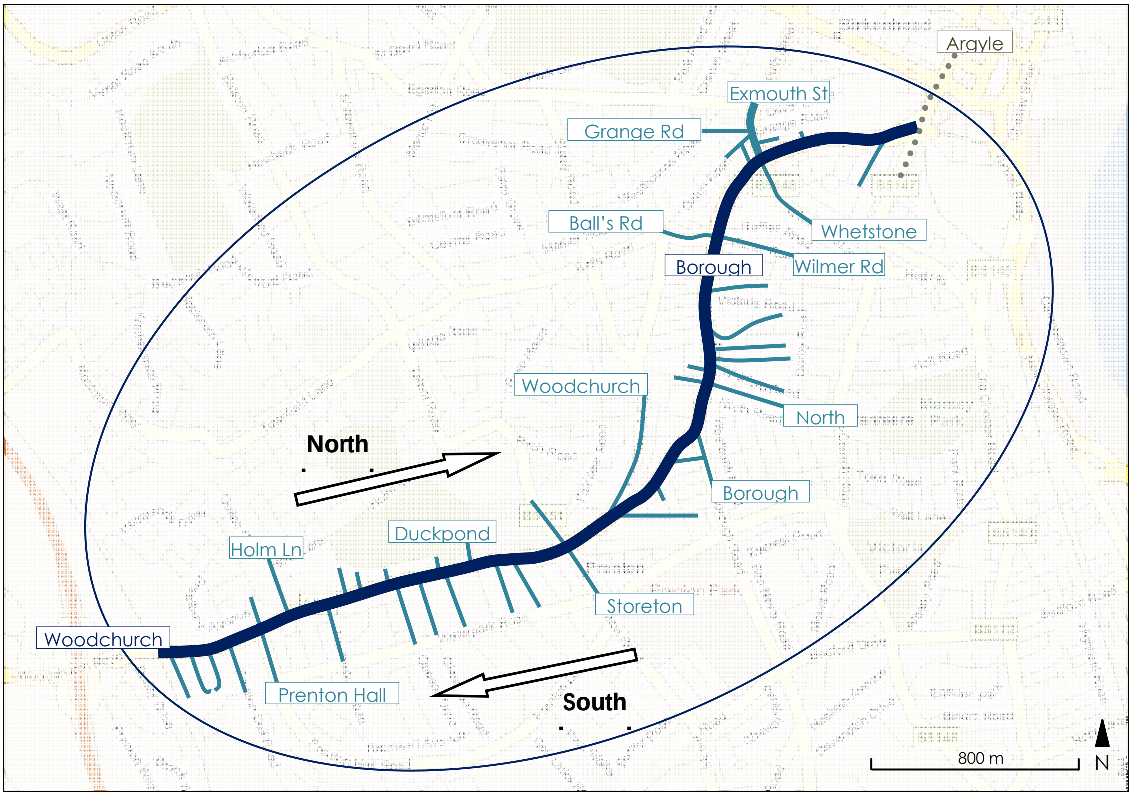
**Figure 14: Included and excluded portions of the A552 to model in VISSIM**




*Source: http://maps.live.com*

It is besides obvious the model has to take into account all the trips entering and leaving the adjacent access roads of the corridor, even when they represent a marginal part of the total movements, as any vehicle joining the modelled track of the A552 enters in conflict with the others and affects the global traffic performance. Thus these roads, amid which many are just linking residential areas to the corridor, will be added to the simulation with their length being partially modelled as they will only be used to attract and generate traffic from and to the corridor. The total perimeter of the network that will be virtually reproduced can then be seen in Figure 15.

**Figure 15: Perimeter of the network to reproduce**



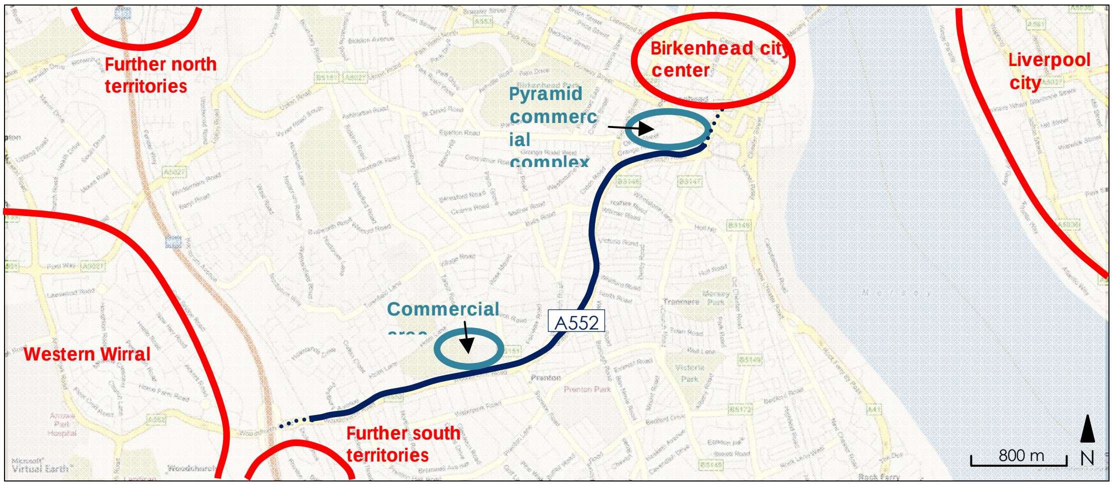

*Source: http://maps.live.com*

It is to notice the modelled portion of the A552 includes another A-road which crosses it perpendicularly in the north eastern area, close to the Birkenhead town centre: the A5029 is indeed connected via the Exmouth Street, that links the A552 to the A553 further in the north of the city. This infrastructure will be the only modelled adjacent road to include a signalised junction on its route (Exmouth Street/Oxton Road/Grange Road West) as this junction controls a consequent traffic coming from various points of the sector in the proximity of the A552. All others A552's bordering streets don't take in any signalised intersection close to the corridor.

The corridor mainly provides accesses to the numerous residential areas of the sector, which cover the well-nigh totality of the territory that will be virtually reproduced. Notable trip generators are then very few along the infrastructure (most are supposed to be outside the network, as Figure 16 shows): only the two commercial areas roughly located around each of the two route's extremities can be considered as markedly attractive within the selected network. The first one is laid near the junction Woodchurch Road/Duckpond Lane, it includes several medium-size shops and provides important parking capacities. The second one is the imposing Pyramid commercial complex situated around the Argyle Street/Borough Road roundabout junction at the network's very eastern area: the building and its high-capacity parking take up a very large place in this sector, and the equipment is seemingly the first attraction point located along the A552.

The main outer-perimeter production and attraction points are, as for them, expected to be mainly found in the Birkenhead city centre (to which the A552 provides direct access in the east), Liverpool (accessed via the Mersey Tunnel, to which the A552 is connected), western Wirral (reachable thanks to the corridor in the west), and further territories accessed via the M53 to which the corridor is linked.

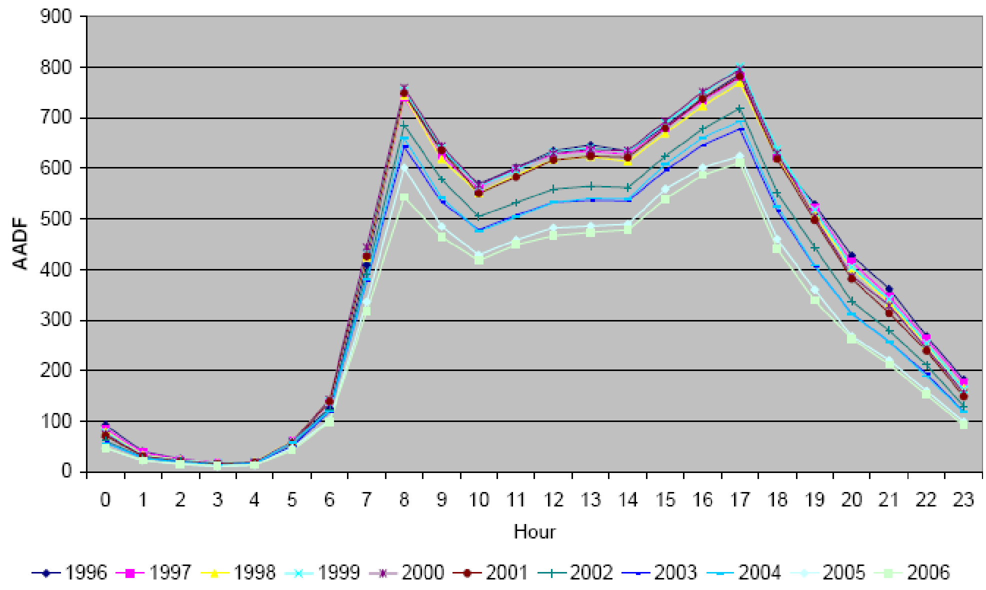
**Figure 16: Supposed main trip generators within and outside the corridor**




*Source: http://maps.live.com*

As far as the time period for the simulation is concerned, this project will follow DfT's recommendations to model corridors for an AM and a PM peak period (when congestion is at its highest level), as traffic movements vary throughout the day and the network has to be able to cope with these unbalanced trips. But unlike the government body's suggestion that consists in achieving traffic simulations for long periods (7:00 - 10:00 and 16:00 - 18:00), which may delay the simulations unnecessarily as huge input data would have to be defined (transport demand still fluctuates within these intervals, and demand estimation processes would be extended too much), this study's strategy is to select only one-hour AM and PM periods in which traffic hits the highest peak. By referring to the Wirral traffic profile (Figure 17), it appears flows are at maximum at 8:00 in the morning and 17:00 in the afternoon, thus the model can follow from these data: the simulation will be proceeded for 8:00 - 9:00 and 17:00 - 18:00 time periods, with fifteen-minutes pre-peak intervals before each period to allow for reproducing free flow traffic conditions as well. Then demand will have to be estimated for only four time intervals (7:45 - 8:00, 8:00 - 9:00, 16:45 - 17:00 and 17:00 - 18:00) and the model will include all the most representative traffic conditions.

**Figure 17: Wirral traffic profile (Monday to Thursday)**




*Source: Mott MacDonald Merseyside Information Service (2007)*

### 3.2.2. Roads and roads connectors reproduction

The first real modelling step of the process is rather meticulous: any street included within the selected network's borders has to be replicated utterly in VISSIM, along with some basic characteristics. This stage needs to be achieved in the most painstaking way as the virtual traffic simulation that will be operated subsequently depends in a crucial part on the basic coding regarding the diverse infrastructures.

Thus additionally to the virtual representation of the network roads, which is carried out manually in VISSIM with the help of a digital background photograph of the area adjusted to the software's scale, a range of fundamental parameters have to be set up for each new created portion:

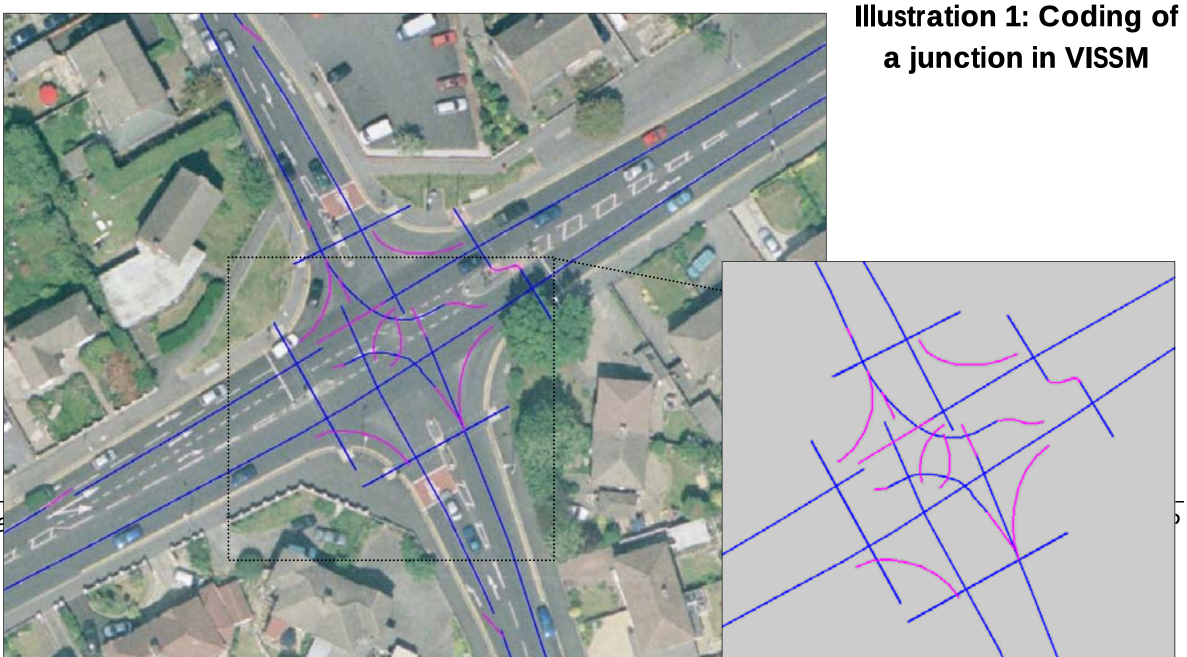
- **length of the road or road section**, based on the real network's tracks dimensions, and reproduced precisely in the microsimulation tool.
- **number of lanes**, based on the real design of the network infrastructures and taking into account layout changes on the maximum level of detail, *i.e.* even changes of the number of lanes over very small road's sections are coded rigorously.
- **width of the different lanes**, also based on observed measurements, replicated following the background and considering each more or less important layout change in the real network.
- **permitted user classes on the infrastructure**, which allows to include and exclude defined vehicle types among the network's users on any infrastructure in order to fit to the real local traffic rules. It appeared useful to code the corridor's bus lanes, on which cars, pedestrians, heavy goods vehicles (HGVs), light goods vehicles (LGVs) and motorcycles are banned whereas cycles are authorized. On any other road segment of the corridor all vehicles are allowed to run (apart from buses when they have a parallel specific lane, obviously), and on foot path only pedestrians can walk.
- **behavior types**, which lets the possibility to load a specific behaviour algorithm for the infrastructure's users, this algorithm depending on the road type (motorway, urban road, footpath, cycle track *etc.*) and the way users are expected to conduct themselves on this particular road type. The algorithms are pre-established programs that include complex coding to reproduce driving attitudes as realistically as possible, with variable functions and parameters such as car following model, lane change acceleration and deceleration, reactions to amber signals, speed adjustments nearby traffic lights, or temporary lacks of attention. Because any slight change in these programs is likely to lead to consequent (and maybe undesired) changes on the simulation results, the Birkenhead model will be exclusively using the pre-existing functions of the software which follow from accepted UK-based studies (outside London). And because all modelled roads of the network are urban infrastructures, the behavior algorithm chosen for these segments was

"urban", when the comportment types selected for footpaths and cycle bands were respectively "footpath" and "cycle tracks".

- **lane closures**, which allows to define as authorized or unauthorized, for all or particular user types, the possibility to change lane on a road. It can be used, in some peculiar situations, to monitor driving behaviours on an infrastructure such as vehicles remain on their lanes, in an attempt to make vehicle movements more likely to match up with reality (*e.g.* when, on a specific network portion, lane crossing appears unlikely in reality because of insecurity). Regarding the Birkenhead corridor, no lane closures were deemed necessary to be coded amidst all network's sections.

Seeing that all roads or roads sections are created separately in the software, they stand actually for individual network pieces without any interaction with each other and don't allow the VISSIM model to run. Therefore they all need to be linked with connectors, which allow to model complementary paths between road segments, and permit the miscellaneous individual tracks to constitute a complete road network. Connectors are then useful to design road intersections, on which a multitude of connections need to be coded to respect all possible routes across the network. The next illustration (Illustration 1) shows a particular junction of the corridor, which has been virtually coded with its approach arms (blue lines) and its connectors (pink lines) that link the arms and create all turning possibilities over the intersection.

**Illustration 1: Coding of a junction in VISSM**



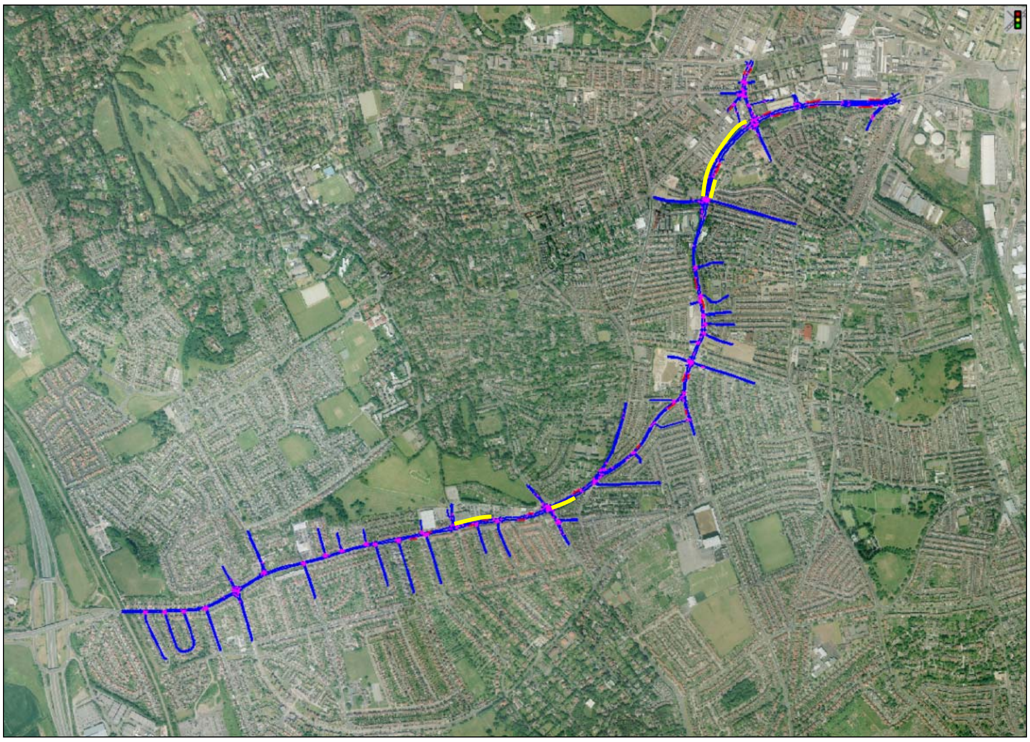
*Source: VISSIM illustration*

As VISSIM connectors are also road segments on which users can run, they embrace the same coding parameters as roads which have been depicted so far, plus two specific and strongly important others:

- **lane changing start**, that invites to set up a distance from the connector, from which vehicles are allowed to cross lanes in order to reach the connector (the targeted connector being chosen depending on the individual path decisions). Beyond that distance, drivers can use every lane of a road whatever their ongoing destination is. In the Birkenhead model, these start distances vary from their locations in the network, they were adjusted in function of the local road layout and the drivers' presumed crossing lane behaviours on these specific locations.
- **emergency stop**, which allows to define, similarly to the lane changing start distance, a space from the connector, after which vehicles are no more permitted to cross lanes to reach this connector. It is used to ensure users have chosen their path sufficiently upstream the connector and prevents from unrealistic merges in the proximity of junctions for example. As the previously mentioned parameter, emergency stops were coded depending on local conditions and were every time adjusted to the most realistic merging likelihoods.

The next illustration (Illustration 2) shows, finally, the utter modelled network such as it can be seen in VISSM. The four short bus lanes the corridor takes in are highlighted in yellow: a 120 m (393.7 ft) bus-reserved segment on the western side of the junction Woodchurch Road/Duckpond Lane (for the north bound only), close to the commercial area, a small 90 m (295.3 ft) lane on the Singleton Avenue around the junction Woodchurch Road/Singleton Avenue (south bound only), a longer 310 m (1017.1 ft) lane on the Borough Road, between the junctions Borough Road/Ball's Road East and Borough Road/Whetstone Lane (north bound) and finally a 90 m (295.3 ft) one in the other direction of the street (south bound), upstream the junction Borough Road/Ball's Road East.

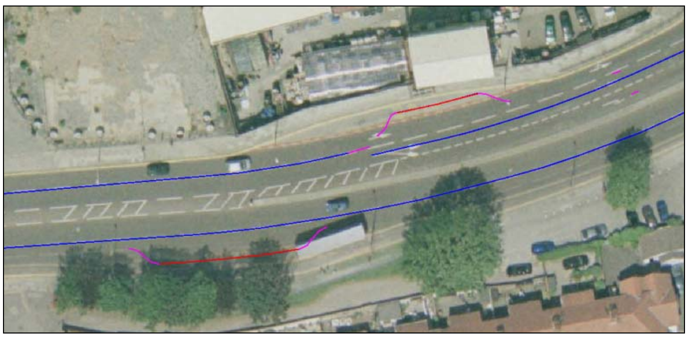
**Illustration 2: The Birkenhead corridor: modelled road segments and connectors**



*Source: VISSIM illustration*

None of the bus-reserved segments take up the whole road spaces, all are located parallel to the corridor's private vehicles lanes (see Appendix 13, page 112). All in all, the network takes in a total 24 bus stops spread across the route, amid which 10 are located on the corridor's north bound, 10 on the south bound, the last 4 being laid over the access roads (downstream from the junction Borough Road/Singleton Avenue for the first, and Oxton Road for the second). All bus stops were virtually coded according to their real locations, and the model will obviously distinguish on-street and lay-by bus stops. Lay-by stops were modelled thanks to connectors joining the main road, opened up exclusively for buses, and materialized as portrayed in Illustration 3:

**Illustration 3: Bus stops coding in VISSIM**

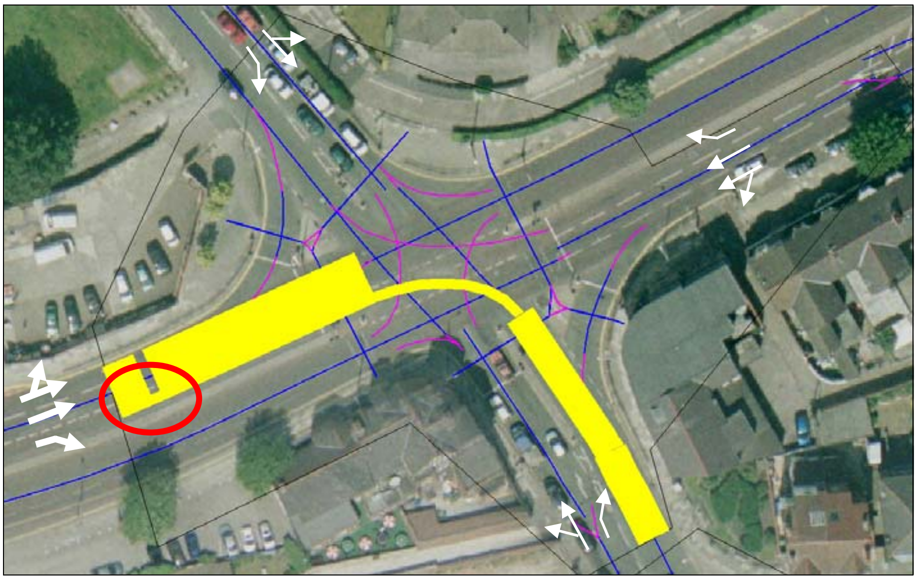


*Source: VISSIM illustration*

### 3.2.3. Nodes and turns shaping

Even though all junctions have been virtually designed in the previous step, with connectors joining every relevant road segment to model the different turning options, VISSIM needs to understand on which lanes of the nodes' approach arms it will allow or ban vehicles to place themselves before turning. Based on the real markers information that are specified along the corridor's roadway, the turns coding was then carried out within each VISSIM node delimitation, as Illustration 4 portrays. Once traffic will be generated, vehicles routes will have to follow the defined paths by using the relevant connector (red circle on the figure, which point the only lane authorized to turn right from the left arm).

**Illustration 4: Turns coding inside VISSIM nodes**



*Source: VISSIM illustration*

This coding compels virtual users to chose their lane sufficiently downstream the node, as in real traffic conditions, and makes it achievable to avoid unrealistic vehicles movements over the approach of intersections.

### 3.2.4. Definition of the traffic composition

To lead to correct and valuable results, the microsimulation model is to replicate strictly the same composition of traffic as the one which can be observed in Birkenhead. VISSIM allows to proceed to the vehicle types distribution in an accurate way: once the vehicle classes the model will use are chosen, the software invites to specify the proportion of each defined vehicle class that will be included in the total traffic, as well as a speed range related to each category.

The virtual corridor network will embrace the usual Birkenhead traffic composition, which was already mentioned: cars, buses, HGVs, LGVs, motorcycles, cycles, and pedestrians. Concerning walk trips yet, despite pedestrian crossings have been modelled in the previous step, no pedestrian demand will be assigned immediately in the model. In the case of the Birkenhead route indeed, the impact of pedestrian demand on global traffic conditions is considered too slight to be materialized along with the other vehicle classes that share the road. The model will then consider people on foot as independent of the congestion issues the simulation is supposed to resolve. But the model already owns pedestrian equipments, it is flexible enough and ready to consider walk trips in the traffic as part of a later option testing eventually.

As far as cars, HGVs, LGVs, motorcycles and cycles are concerned, their proportion in the network traffic will be based on very recent counts operated on certain junctions of the corridor, but these proportions are not to be set up at this step of the model building: they will actually follow from the dynamic demand creation expounded in the next chapter of this document (Part 4, page 65), which will automatically generate traffic with the relevant modal shares. As for buses, their amount in the traffic will be defined in the public transport lines coding, one of the next model building's steps.

Some vehicle types proportions have however to be fixed inside each vehicle class: the cars class, for example, is a large category itself which encompasses several sub-categories of vehicles having different lengths, various axle sizes, taking up more or less space on the network and then resulting in different impacts levels on the traffic. Within the scope of this study, the sub-categories distribution will be the one Mott MacDonald uses for all its simulations regarding UK projects: the cars class will then contain 5% taxis and 3% sport utility vehicles (SUV), the rest being divided into the usually observed vehicle models across UK (city-cars, saloons, family-cars, sport cars, *etc*.), HGVs will include as many medium trucks as heavy ones, LGVs will be composed of 70% vans and 30% step vans, the motorcycles category will be shared equally between scooters and powerful motorcycles, and finally buses will include exclusively double-deck vehicles. It is to notice these sub-categories are only distinguished from themselves by their dimensions, their speeds being considered as equivalent within each sub-group.

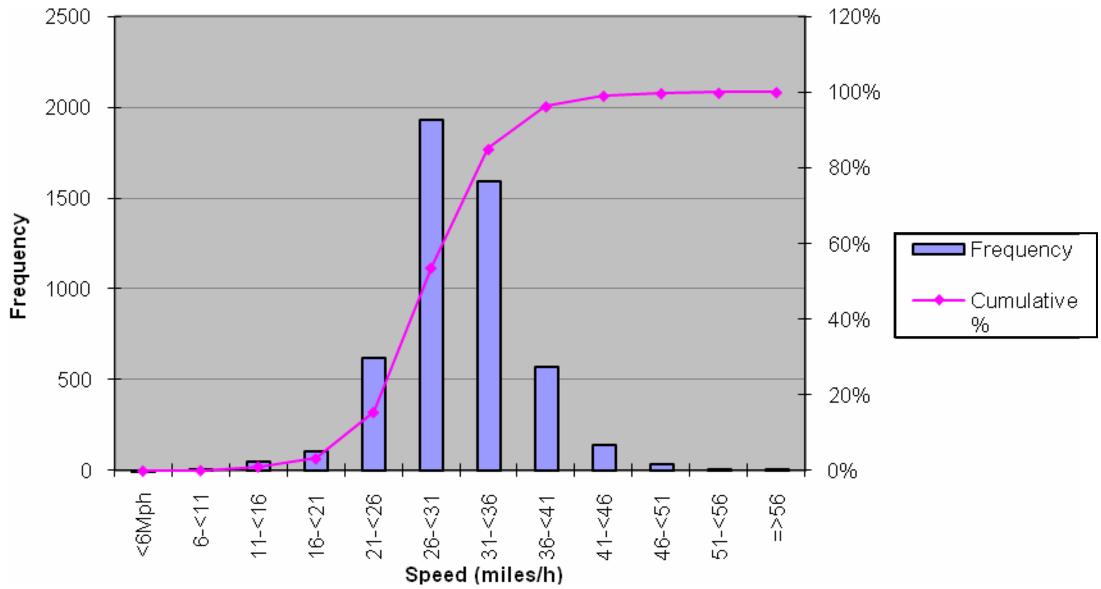
The last parameter that can be defined in the traffic composition stage is the speed distribution proper to each vehicle type, which allows to determine how fast the different users classes run on the whole network. But as this study's strategy is to code speeds with a high level of detail, speed indications will be set up for each road category and will vary from the localization on the corridor. These parameter will then be entered in the following step of the building process: the desired speed distributions.

### 3.2.5. Desired speed distributions

On the near totality of the Birkenhead corridor network, the speed limitation is 48.3 km/h (30 mph), the common boundary that can be found in UK urban sectors. The only road portion whose limitation differs is the very western segment of the modelled corridor, from the railway bridge to the first intersection (Woodchurch Road/Palmwood Close), where drivers can't exceed 64.4 km/h (40 mph).

As real speeds are expected to rise frequently beyond these theoretical limitations, the model resorts to one of the only relevant outputs available, which results from the local automatic traffic counts (ATC) survey: the Birkenhead speed frequencies histogram (Figure 18). Observations were carried out on the A553, the A552's neighbouring A-road, during a 2006 week (week-end excluded), and measured how fast ran all motorized vehicles on this representative urban infrastructure. Despite it gathers measures for all vehicles types without considering their possible speed differences, which stands for a disadvantage, this output will be used to help defining desired speeds intervals for the Birkenhead model, as well as the dimension range of intervals previously coded in the latest Mott MacDonald projects. The lack of data concerning individual users classes implies the specification of parameters for each vehicle type is likely to prevaricate the model's results, therefore the simulation will be roughly considering all motorized vehicles run at the same speed in the network (only cycles having their own interval). But as VISSIM vehicle types will possess various acceleration and deceleration pre-defined functions (based on studies carried out across UK by PTV, the company that created VISSIM), and as the software will be replicating urban high-traffic conditions, with low speed limitations, rarefied speed peaks and generally evened mean speeds, the model is anyway expected to remain pertinent. The impacts differentiated speeds could bring about the final results are then estimated marginal.

**Figure 18: Speed frequencies on the Birkenhead's A553 (Conway Street)**



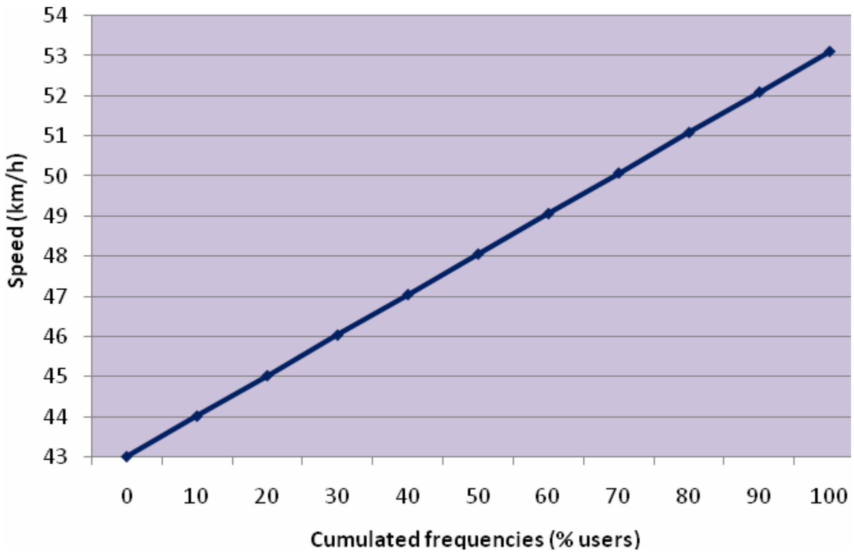

*Source: Mott MacDonald Merseyside Information Service (2006)*

It can be observed a strong majority (nearly 65%) of the motorized users drive with speeds comprised between 26 and 36 mph (41.8 and 60 km/h), the mode being clearly the 26-31 mph (41.8 - 50 km/h) interval. As speeds across the corridor to model may globally correspond to the surveyed vales, it has been counted a close interval should be used, without reaching the high 60 km/h (36 mph) figure, for the VISSIM desired speed distribution of motorized vehicles (cars, buses, HGVs, LGVs and motorcycles). The decided interval is then 45.9 - 54.7 km/h (28.5 - 34 mph), inside which speeds of all drivers of the model will be found. It includes approximately the two most frequent observed speed distributions and stands for a pertinent parameter within the framework of the model.

Since roads present various capacities on the modelled network, they are not expected to allow for the same speeds and motorized users have to adjust their behaviours in function the infrastructures' design. The necessity to set up different speed distributions for each road type of the model appears then: hence, the 64.4 km/h-limited (40 mph) western section of the A552 will experience a faster 56.3 - 67.6 km/h (35 - 42 mph) interval, when the corridor and its largest access roads will be limited to 43 - 53.1 km/h (26.7 - 33 mph), narrower adjacent streets will see a 25.7 - 33.8 km/h (16 - 21 mph) distribution and very small modelled roads (residential paths, *etc.*) an only 23 - 25.4 km/h (14.3 - 15.8 mph) interval. As far as bikes are concerned finally, their speed distribution will be constantly fixed to 19.3 - 32.2 km/h (12 - 20 mph) whatever the road type is.

These VISSIM speed distributions' peculiarity is their frequencies distribution are constant within their intervals: unlike reality, the frequency of users driving at any speed of the intervals has always the same value, and cumulated frequencies' curves are strictly linear between the interval's lowest and highest bound (illustrated in Figure 19 with the example of the corridor's speed distribution, cumulated frequencies being on the abscissas axis).

**Figure 19: Desired speed distribution of the Birkenhead corridor (43 - 53.1 km/h): cumulated frequencies**




*Source: Excel calculation*

Frequencies were coded in a constant way to simplify reality, as data regarding speed distribution issues were missing in Birkenhead. The speed frequencies figure showed further back scarcely concerns a specific type of road in the city and didn't allow to make rigorous assumptions for other types of infrastructures. That is why it was chosen to use linear cumulated frequencies for all VISSIM speed distributions.

It is to specify, to end with, that VISSIM asks for a time interval delimitation inside which the coded speed distributions apply, the outer-interval's periods letting users choose the speed they want. This parameter is useful to monitor speed variations throughout a period during which speed-related behaviours are expected to vary. But in this simulation's context speeds are reckoned even, hence no specific time-depending speeds will be set up.

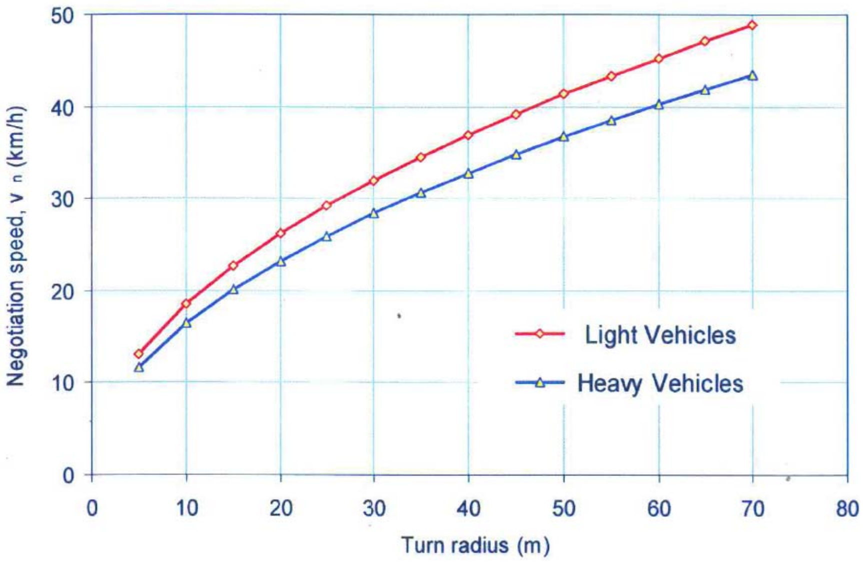
### 3.2.6. Reduced speed areas coding

Even though desired speed intervals have been coded to define how fast users should drive across each segment of the modelled network, the model has to take into account all specific locations where the roads design force drivers to slow very temporarily. It is notably the case when they approach bends, when they turn at junctions and in any case when they have to steer even slightly to carry on with their paths. Therefore, small reduced speed areas need to be implemented across the network in the VISSIM model.

Desired speed areas require the same parameters as the desired speed decisions to be coded, namely the definition of a speed interval users will respect scrupulously by adjusting their behaviour. They are simply use additionally to the desired speed decisions to materialize the short, unpredicted, and obviously undesired speed changes drivers have to cope with in an urban network such as the Birkenhead corridor.

To know how vehicles generally adapt their speed when they have to turn, the model resorts to previous results of a research pertaining to negotiating speeds on roundabouts[5]. Figure 20, which deals with relations between turn radius and negotiation speed for heavy and lights vehicles, is extracted from this work.

**Figure 20: Negotiation speed as a function of the turn radius**




*Source: Akcelic & Associates Pty Ltd (2002)*

From this output showing negotiation speeds globally increase with turn radiuses, and in a simplification attempt, only three turn types will be defined for the model with their proper negotiation speed: short-radius, medium-radius and large-radius turns. The short-radius turns will be defined such as their radius is 5 to 15 m (16.4 to 49.2 ft), medium ones will have 20 to 30 m (65.6 ft to 98.4 ft) radius, and large ones 35 to 45 m (114.8 to 147.6 ft).

The graph above gives then, for each selected turn category, speed intervals for light and heavy vehicles which will allow to distinguish user types from each other more precisely without dread of hedging the model. In the first turn category, that will be used for the tightest bends, speed intervals are theoretically 13 - 23 km/h (8.1 - 14.3 mph) for light vehicles (cars, LGVs, motorcycles) and 11 - 20 km/h (6.8 - 12.4 mph) for the heavy ones (HGVs and buses). But the light vehicles' interval has been deemed too slight for the model as it could cause exaggerated slowing down during the simulation: it was finally adjusted to previous models' range of values for this type of turns, namely 19.5 - 29.4 km/h (12.1 - 18.3 mph). For the second category, which will be concerning smoother bends, speed intervals were settled to 27.7 - 33.8 km/h (17.2 - 20.9 mph) for light vehicles and 23 - 29 km/h (14.3 - 18 mph) for the heaviest

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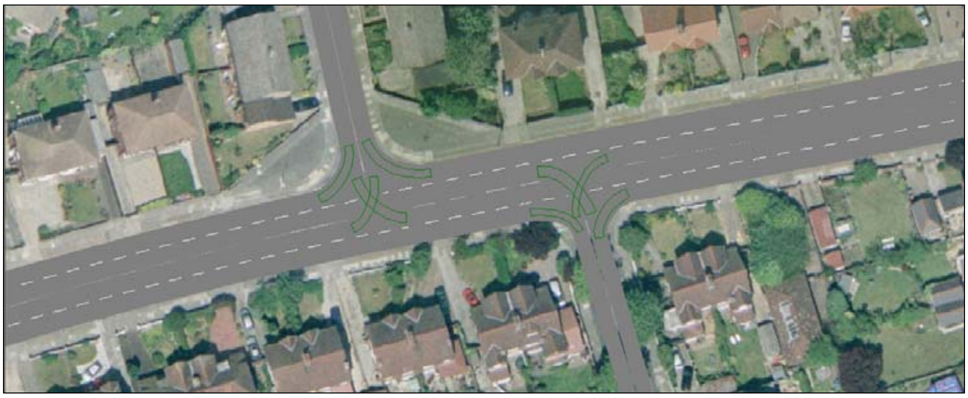
[5] *Estimating negotiation radius, distance and speed for vehicles using roundabouts*, Akcelic & Associates Pty Ltd, 24th Conference of Australian Institutes of Transport Research, Sydney, 2002.

ones. To finish, the third category's speed ranges, adapted to the model's largest bends, will be 35 - 39 km/h (21.7 - 24.2 mph) for light vehicles and 31 - 35 km/h (19.3 - 21.7 mph) for heavy ones. As for cycles, they will not be concerned by reduced speed areas, the model will consider they maintain a regular speed across the whole network. Their speed values over reduced speed areas will then be the same as their desired speed distribution on the entire corridor: 19.3 - 32.2 km/h (12 - 20 mph).

Illustration 5 shows a VISSIM reduced speed area coding (green rectangles), with the example of junction medium turns. These areas are always fairly short and drivers are allowed to attain again their usual desired speed as soon as they leave the small slowing down zones.

**Illustration 5: Reduced speed areas coding in VISSIM**



*Source: VISSIM illustration*

Is to notice, finally, that VISSIM requires a deceleration value for each vehicle type to be settled, to model its behaviour when it is compelled it to adjust its speed on short distances: these deceleration values were fixed at 2 m/s² (6.6 ft/s²) for cars, LGVs, motorcycles and cycles, and only 1.5 m/s² for HGVs and buses which are expected to brake on shorter distances.

### 3.2.7. Priority rules coding

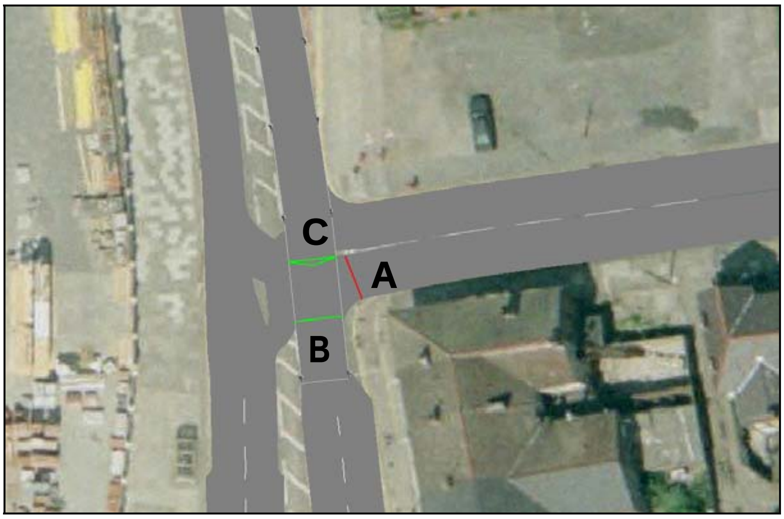
If the simulation is to be as close to reality as possible, priority rules on the modelled network need to be reproduced scrupulously as their contribution on global traffic conditions is significant. VISSM allows for specifying stops and give ways locations, with flexible parameters that can be adjusted for each conflict area and thus provide highly detailed virtual replications.

Within the selected space perimeter to model, all unsignalised conflict zones are give ways, no stops are included. Illustration 6, extracted from VISSIM, permits to watch how a give way is coded: the red mark on the road (A) materializes the exact location where vehicles must stop on the access road, and the first green mark (B) is the conflict marker on the main road that reproduces the site to which vehicles of the adjacent street must give priority (once drivers of the main infrastructure have utterly crossed this mark, vehicles which have stopped on the perpendicular road can move forward). To define in which conditions a vehicle can cross the access road when it hasn't the right of way, the microsimulation software invites to specify two main spatial and temporal parameters:

- **minimum driving time upstream the conflict marker (B):** this parameter sets a minimum time period to reach the conflict marker from any vehicle location on the main road. Within this time period, users of the access are not authorized to move forward as they don't have enough time to do it (provided vehicles which have priority continue travelling at their current speed). Beyond this period, adjacent road's vehicles have sufficient time to cross the stop line (A), they don't have to give priority and carry on with their routes without stopping.
- **minimum distance upstream the conflict marker:** conspicuously materialized with the second green mark (C), this distance is the space delimitation which determine whether adjacent road's vehicles can cross or not. As long as any user of the main infrastructure is located within this delimitation no user from the access street is allowed to move forward, crossings becoming permitted only when the area is entirely free.

So that vehicles of the access road can cross the stop line, both of these conditions must be in their favour.

**Illustration 6: Give way coding in VISSIM**

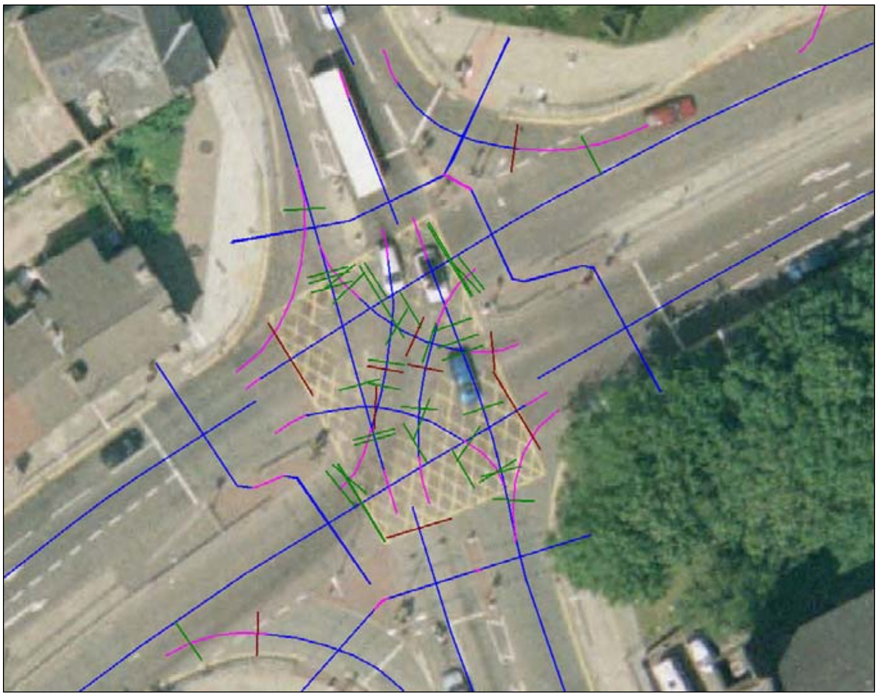



*Source: VISSIM illustration*

Over most of the network's unsignalised conflict areas, the minimum time to give priority was fixed at 3 s and the minimum distance at 5 m (5.5 ft). But like many VISSIM parameters, these values had to be coded slightly differently in a few situations, when peculiar roads designs or give way signal locations led to unrealistic driving behaviours. Though the range of values doesn't not wobble a lot finally.

To end with, several priority rules have also had to be settled on signalised junctions, as they operate in complement of traffic lights. Moreover in UK, large yellow rectangles are drawn on the ground over the most frequented road intersections, to mark off a space vehicles should not enter when a high traffic prevents from fluid movements (Appendix 14, page 112). In the Birkenhead network, two signalised intersections possess yellow boxes (Borough Road/Ball's Road East and Borough Road/Whetstone Lane). Both were coded with complex priority rules reproducing real yellow boxes, as Illustration 7 shows for the Borough Road/Whetstone Lane junction (the red marks materializing the different stop locations across the intersection, and the green ones being the diverse give way locations to which vehicles must give priority when they are not allowed to cross).

**Illustration 7: Yellow boxes coding in VISSIM**



*Source: VISSIM illustration*

### 3.2.8. Traffic signals coding

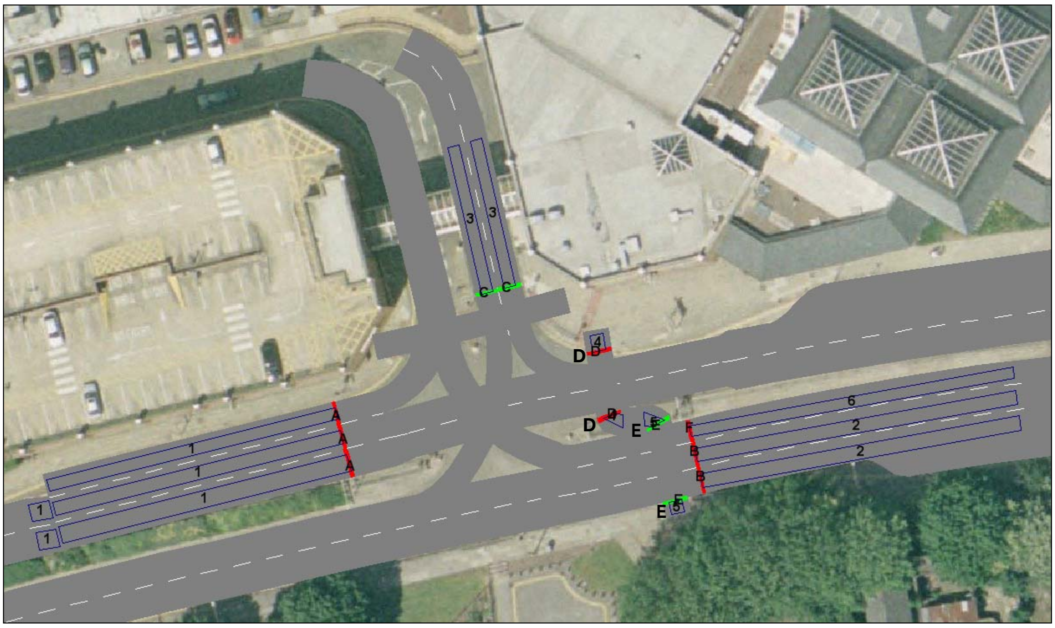
Traffic lights take part, as well as priority rules, in the vehicle flows control. Within the scope of this journey times lessening project, they will be playing a decisive role: they are indeed one of the strongest lever when flows that are thrown into turmoil need to be balanced, and stand for a very valuable tool in the attempt of mitigating jams. As for public transport supply across the network, bus services performances are likely to be very significantly impacted by measures applied on signal timings.

Subsequent testing will include, for instance, bus priority measures on signals, therefore the model has to be rigorously faithful to the real signal stages successions that are operated over the network.

The corridor and its access roads encompass eleven signalised junctions (Appendix 15, page 113), of which five are three-arm and six are four-arm. In addition, five signalised footpaths are laid individually on several points of the network, allowing pedestrians to trigger red lights on the main road whenever they need to cross. Footpaths have been reproduced in VISSIM, but as no pedestrian demand will be assigned immediately their signal coding will not be achieved in is stage.

All these signalised intersections are vehicle actuated (VA), *i.e.* signal stages successions are triggered in function of the approach arms' demand. Vehicles are located by detectors placed around 30 m (98.4 ft) upstream the lights (as shown in Illustration 8, after the VISSIM coding), which automatically transmit information to the system and activate the next programmed stages. Red, green and obviously cycle times (time periods that elapse from the beginning of a particular stage to the beginning of a new one) are not fixed. The only fixed lengths are for amber (3 s) and red/amber (2 s) signals. It is reminded that in UK, amber times succeed to green times whereas red/amber times succeed to red times before the start of a new green signal.

**Illustration 8: Signal heads and detectors coding in VISSIM**




*Source: VISSIM illustration*

It can be observed on the figure each detector number (1, 2, 3,…) corresponds to a particular signal group (A, B, C, …), all these groups being activated by the demand got on specific detectors.

The VA signal timings coding is complex and requires using a programming language outside VISSIM. Two essential files are needed as inputs to the virtual signal timing functioning: the interstages definition file, and the logic files that provides VISSIM with information about stage changing conditions. Both are based on very precise data related to the various green and red times, collected from Wirral's authorities: minimum and maximum green times, as well as interstages times, will then be scrupulously based on the real ones.

The first file allows VISSIM to understand what signal groups are to be activated in each individual stage, and defines the intergreens lengths, *i.e.* the time period, between two successive stages, within which no green signal is activated. The second is a program, whose language is on the same model as the most widespread programming tools, which defines every condition necessary for one stage to be followed by the next one (taking into account and connecting demand on detectors, minimum green times, maximum green times for each signal group). As an example the condition that allows the stage running on the illustration further back (stage 3), in which signal groups C and E are activated, to be replaced with the next one (stage 1) in which groups A and B will be green, can be programmed as follows:

```
If ( (Green_Time_Group_C >= (Minimum_Green_Time (Signal_Group_C) ) And
        (Green_Time_Group_E >= (Minimum_Green_Time (Signal_Group_E) ) )
        Then
          /Signal groups C and E are both activated, then the stage running is
        stage 1

        If ( ( (Detected_Demand_Group_C = 0) And
        (Detected_Demand_Group_E = 0) ) And (
        (Detected_Demand_Group_A >= 0) Or (Detected_Demand_Group_B >=
        0) ) ) Then /Condition: if there is no more demand for signal groups C
        and E, whereas there is demand either for signal group A or B

                Interstage (3_to_1) /Stage 1 substitutes for stage 3

                Else

                If ( Green_Time_Group_C >= (Maximum_Green_Time
                (Signal_Group_C) ) Then /Condition: if signal group C
                reached its maximum green time (the pedestrian signal group is
                not considered in this condition as it has no maximum green
                time)

                        Interstage (3_to_1) /Stage 1 substitutes for stage 3

                End

        End

End
```

When bus priority testing will occur, it will merely be required to create detectors especially for buses, and the interstage programs will automatically activate the relevant stage allowing them to move forward when they will be approaching their detectors.

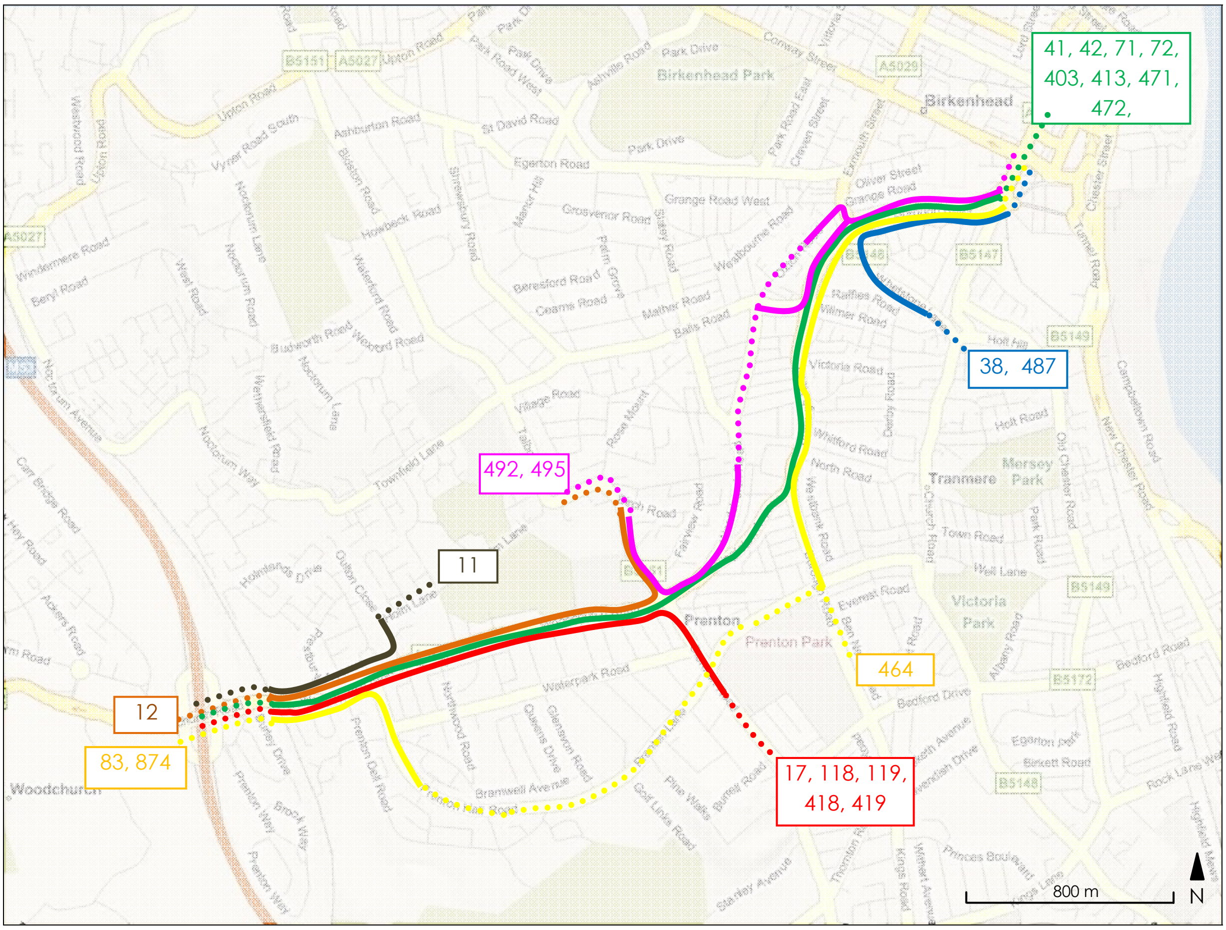
### 3.2.9. Public transport lines coding

Bus services' efficiency is a major issue throughout this study. Attempting to improve the performances of buses supply, by reducing their journey times, stands out for a decisive way to attract again a slumping public patronage to the corridor's public transports and fight against the surging use of car. As this project will ultimately take in a range of tests regarding bus services, the VISSIM model has first to virtually reproduce the exact movements of vehicles at the exact times. For that, it has been resorted to information from Merseytravel, the local public transport coordinator that acts in partnership with private bus and rail operators to provide public transport services within Merseyside. All relevant bus timetables, available on the Merseytravel website, will be used to specify virtual start times in the model, which will only be taking into account the services starting their route over the AM modelled peak (7:45 - 9:00).

On the modelled segment of the A552 and its adjacent roads, not less than 55 bus services are counted. But actually, 23 of them run outside the selected simulation period: most have strictly the same routes as many services operating between 7:45 and 9:00 AM but provide service only on Saturdays, Sundays, early mornings, late evenings or during off-peak periods of the week. Their number are distinguished from their equivalent AM peak services because of these different running times and above all as they are carried out by different operators.

The 22 services that will be finally taken into account are the follows: 11, 12, 17, 38, 41, 42, 71, 72, 118, 119, 83, 403, 413, 418, 419, 464, 471, 472, 487, 492, 495, and 874. All operate at least a few meters on the corridor or its access roads (which is enough to prompt conflicts on the infrastructure), as Figure 21 portrays.

**Figure 21: Bus services operating on the corridor over the AM modelled period (7:45 - 9:00)**




*Source: http://maps.live.com*

For each bus route, VISSIM requires the coding of a virtual start time: this start time is not the moment when, in reality, the bus begins its course from its first stop (these first stops being systematically outside the model's perimeter) but the time when the bus starts entering the model on any road of the network, following its coded route. As running times for the model were based on the Merseytravel official timetables, information available were only based on the times buses reach their stops in reality: the moment when they may enter the virtual model was logically never on hand as no bus stops are located exactly on the model's extremities. This compelled to make assumptions over the time periods necessary for vehicles to attain the entrance of the VISSM network from their last stop located outside this network: thus, it was demeed one minute was necessary to reach the eastern entrance of the modelled corridor (Argyle Street/Borough Road roundabout) from the Birkenhead bus station, a multimodal complex situated in the area of the Pyramid commercial zone, the last station where most bus services stop before entering the network. With the same reasoning, two minutes were counted between the last bus stops located outside the network's western entrance (in the close city of Woodchurch), where many buses provide access, and the first point of the modelled corridor. A few other individual assumptions, with similar reckoning, were necessary to finally build a consistent virtual bus network across the corridor. It is to specify that the services whose entrance in the network was estimated just a few minutes before 7:45 AM were included in the model all the same, as they are anyway part of the modelled period traffic and conflicts, with a start time fixed at 0 s (they will be entering the model at the very beginning of the simulation).

The next illustration (Illustration 9) evidences the coding of a particular bus services, the number 17 (yellow line), which passes in transit on a segment of the corridor as its route joins Woodchurch in the west and Bebington in the south of the area.

**Illustration 9: Coding of a bus line in VISSIM**

*Source: VISSIM illustration*

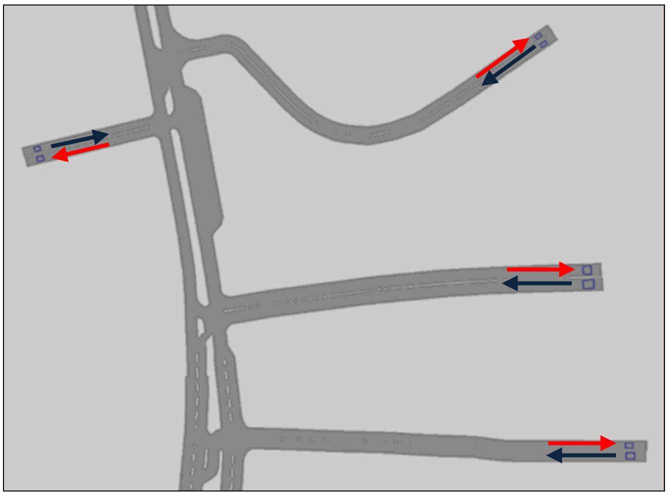
To end with, the microsimulation tool asks for the coding of a dwell times distribution, to model the times necessary for each bus service to pick up customers over the stops. This distribution will apply itself to the whole range of replicated lines. Roughly based on surveys carried out in 2008 over three bus stops of the corridor, the Birkenhead network's dwell times have been settled as their distribution followed a normal function whose mean is 20 s and the standard deviation 2 s. Such a coding implies the model considers bus demand is relatively high at every stop of the network, but this normal function's parameters stood for suitable values in many internal models and will still be expected appropriate throughout this project.

### 3.2.10. Specification of the traffic production and attraction points

In order to generate traffic in the most realistic way, the software invites to specify precisely where the simulation should produce and attract vehicles. These production and attraction points will then be matched with the transport demand data that will be created afterward (Part 4, page 65), to create and attract as many vehicles as the demand matrices will specify.

Hence, a simple coding of the exact traffic's starts and ends locations is required here (Illustration 10): any road of the network must possess production or attraction points (blue squares on the roads' end on the figure) on all its lanes, by minding to set up traffic directions in the relevant way. Over one-way streets of course, only one point is to be settled according to the direction of the lane, to state whether the road is allowed to generate or to attract traffic.

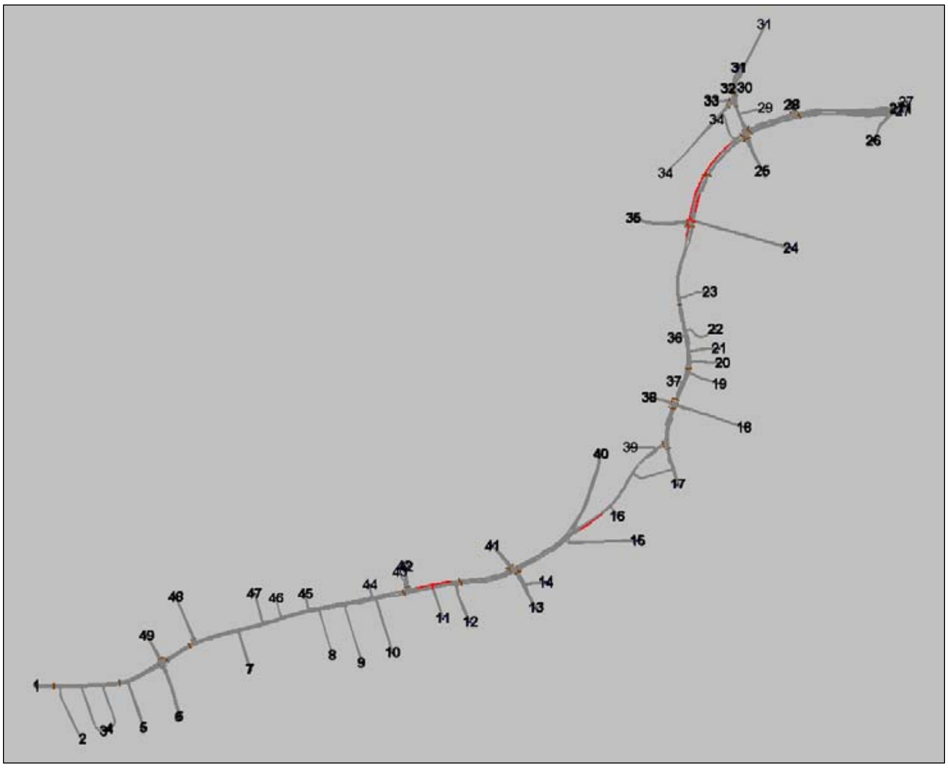
**Illustration 10: Coding of the traffic's production and attraction points in VISSIM**



*Source: VISSIM illustration*

As a result, every extremity of the network is marked with its own origin and destination points. In VISSIM, all these extremities correspond one by one to particular zones which produce and attract traffic in various quantities, each zone possessing its proper zone number. This zonal distinction is hugely important for the ultimate demand assignment stage explained in the next chapter of the document. After the production and attraction points coding, it appears the model takes in 50 different zones (as 50 different segments can generate and attract traffic), as Illustration 11 shows.

**Illustration 11: VISSIM zones over the Birkenhead corridor network**




*Source: VISSIM illustration*

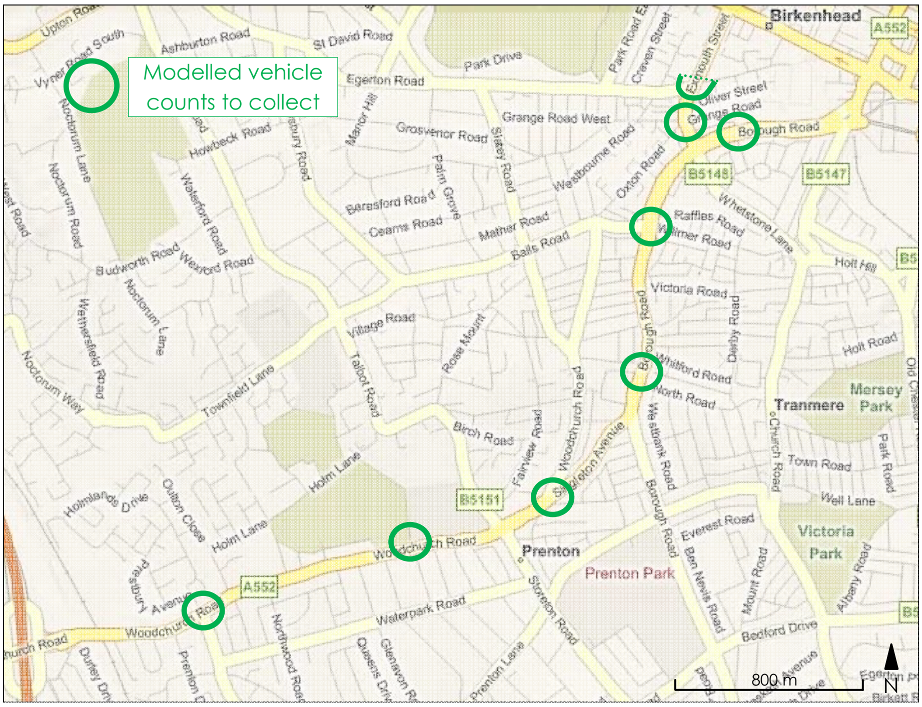
### 3.2.11. <u>Data collection points localization</u>

All the process depicted so far is aimed at allowing to run a simulation of the Birkenhead corridor's traffic. To get the desired outputs from this simulation, and be able to carry out analyses of the congestion issues afterward, it is compulsory to point out VISSIM what type of data the software needs to create and where in the modelled network it has to collect these data.

VISSIM distinguishes collection points for three kinds of data: data related to vehicles counts, data related to travel times, and data related to queues. These three data categories will be used throughout the project and have therefore to be collected the relevant way, that is the coding needs to be done based on what information must be obtained ultimately and where in the network. As this document is utterly focused on the simulation building methodology, the data collection points introduction which is going to be depicted in this section merely concerns information that will be required in the ultimate step of the whole replication process (Part 4, Section 4.3., page 81): the VISSIM model calibration (levelling of the modelled vehicle flows with the real network's observed flows) and validation (levelling up of the modelled travel times with the real network's observed travel times). Additional data will obviously have to be acquired later on, prompting new collection points to settle in VISSIM at first, over the option testing stage which will complete and close the project.

As far as vehicles counts are concerned, the data collection points necessary at this stage are those allowing to number vehicles approaching the junctions for which very recent observed counts are available, as they will permit to compare modelled and observed flows subsequently (calibration process). Figure 22 points these seven intersections (plus a partial one, the junction Exmouth Street/South Claughton Road over the northen extremity of the modelled network), scattered across the network from west to east.

**Figure 22: Required junctions regarding VISSIM vehicles counts**

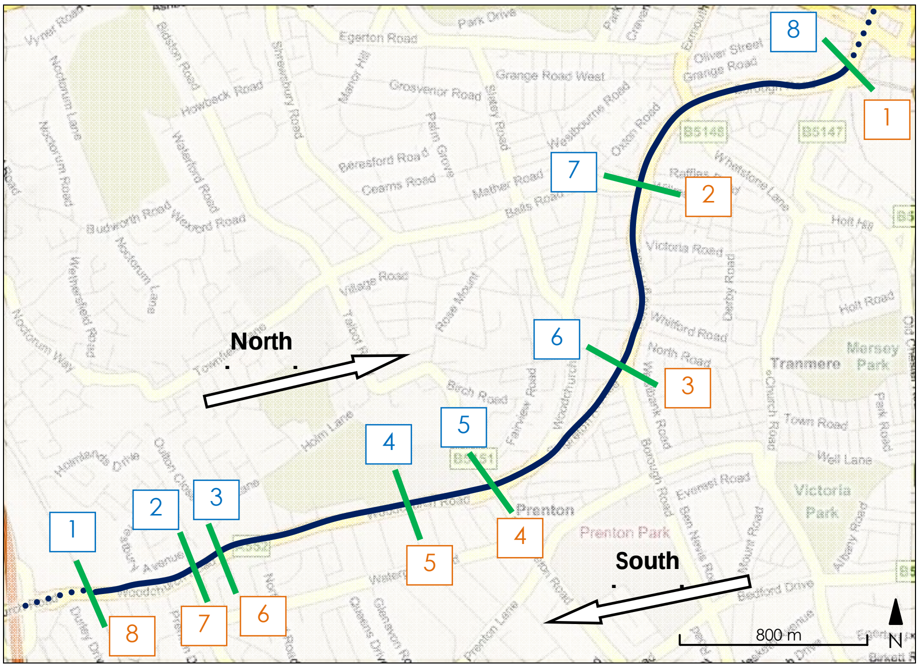



Source: http://maps.live.com

On each of these junctions, collection points have been marked for every approach lane in order to locate all vehicles coming toward the intersection. Each vehicle crossing the count lane will be added to the database.

As for data reckoning travel times, the model will have to be compared with real travel times (validation process), thus VISSIM will need to measure time periods rigorously the same way as the real survey. Virtual travel times checkpoints were then placed on the same road sections as the official data (illustrated on figure 23).

**Figure 23: Required travel times checkpoints to settle in VISSIM**




*Source: http://maps.live.com*

And finally, it was estimated useful to measure some queues around the potentially most congested intersections, in order to identify clearly from which location in the network originate the possible difficulties to calibrate and validate the model. The longer queues will be indeed, the more difficult calibration and validation will be. Thus queue counters were settled on most of the signalised junctions, lines' measures starting from signal heads locations on every arm. To indicate VISSIM the conditions from which it can consider a queue is forming, and allow it to start measuring, two main parameters had to be fixed and both confirmed during the simulation: the vehicles' driving speed under which users are considered to shape a queue, and the minimum length of the line-up beyond which the software assumes it is a queue. For this project, the queue speed was set up at 8.2 km/h (5.1 mph), and the minimum queue distance at 20 m (65.6 ft).

These coding were the last adjustments to set up within the scope of this project and its VISSIM model building process. The model has been put up painstakingly, made as pertinent and realistic as possible through several official data, and is deemed consistent enough to be used for the next stages of the project. However, some limitations are to be pointed out over this process, inescapable within the framework of such a virtual replication. The final analyses will have to consider these drawbacks and mind inexorable uncertainties.

## *3.3. Limitations of the procedure*

Even though the VISSIM microsimulation package is considered a very relevant tool as part of a highly detailed project like this journey times study, using such a meticulous methodology to build the model entails predictable inconveniences.

The software requires coding of hugely precise parameters which have, all one by one, a more or less strong impact on the final simulation results. Any wrongly set up parameter thus stands for a risk toward a significant deterioration of the reality, on which the model is supposed to be based. Broadly speaking, the very high level of detail the model calls for and the logically incomplete database available to cope with this precision implied some simplifications and assumptions to be done. And the obvious lack of time, which accompanies the modelling universe in a recurrent way, did not allow excessive hours consumption moreover when reminding the project is part of a time-based Local Transport Plan.

Regarding particular weaknesses of the model, the absence of pedestrian demand modelling in the base replication can be pointed. Walk trips have been considered too marginally involved in the road users' journey times fluctuations, which can be justified as amblers were proved markedly under-represented (and decreasingly numerous) amid the Birkenhead's miscellaneous transport modes. But with a modal share that is still close to 10% in the Birkenhead city centre, walk trips may actually not be as unimportant as expected across the corridor, even though the infrastructure is not clearly located in the town centre. Taking into account walkers in the simulation, as actors of the original traffic composition and not as an option to test subsequently, may thus have possibly led into slightly different analyses. It is indeed to remind many footpaths across the corridor provide priority to pedestrians, which evidently deteriorates vehicles journey times.

A second limitation, which appeared through the desired speed decision's description, is the evened up speed frequencies' distribution within all defined speed intervals. Coded in a constant way because of the lack of official data regarding speed distributions in Birkenhead, the intervals are then rough simplifications of reality: it is obvious the proportion of drivers running with extreme speeds (lowest or highest) is generally far from being equal to the part of users running with middle-range speeds. Hence the model over-represents very slow and very fast users whereas it under-represents medium-speed drivers, which is likely to impact the simulation results.

Concerning speeds again, the fact all modelled vehicles possess equivalent desired speed distributions in the virtual network (apart from cycles) has been justified further back. This assumption may not be entirely confirmed in every place of the country or the world, but is seemingly suitable for the Birkenhead case. It has anyway to be approved with conviction as coding different speeds for the various user classes can prompt significant changes to the global journey times results. And as for reduced speed areas on the other hand, their classification based on merely three turn types is an evidently coarse assumption, which has to be reckoned as a limitation even if the impacts it entails on the final results are not expected too much significant.

To end with, it is to state the public transport lines coding also includes a range of shortcomings. At first, the fact all virtual running times have been set up in the model according to the AM modelled period's timetables implies PM modelled period will simulate traffic with AM bus running times. Even if the services operating on morning and evening peaks are the same, and their frequencies well-nigh equivalent, their timetables obviously vary and the PM model should not generate buses at the same moments in the simulation as the AM one. The final results might be slightly affected, as journey times and congestion differ with the periods when vehicles are produced and attracted in the model. Another issue related to virtual running times follow from the coding methodology: based on the real Merseytravel timetables which merely inform about arrival times over bus stops, modelled start times for the bus services include, as explained previously, many assumptions to estimate exactly when vehicles enter the network perimeter. These assumptions bring in the same uncertainties regarding times when buses should enter in conflict with other vehicle types on the corridor.

And ultimately, the way buses operate in the model is not exactly faithful to reality: vehicles have been coded as they must stop at every bus stop, even when two or three services are running in succession on the road. The simulation actually considers there is a systematic public transport demand during the modelled time period, equivalently scattered across the network, so that every bus has its own patronage and stops everywhere throughout its route. It is unmistakable buses don't systematically stop in reality, above all when reminding the context of Birkenhead's slumping bus plebiscite. The simulation will then create a maximum conflict level between buses and other vehicles, which will produce over-estimated delays, and what journey times analyses will have to take into account. Concerning buses dwell times, the model will probably distort reality again by reproducing markedly long time periods (20 s mean, with 2 s standard deviation) for all the services to pick up customers. In reality, if several major bus stops are likely to hold back vehicles over so long times, many others don't delay bus travel times so significantly. This high dwell-times assumption may therefore introduce more uncertainties regarding both buses journey times and global traffic conditions.

Despite these relatively minor weaknesses, that will lead to qualify slightly the final analyses, the model is ready and able to stand for the expected virtual medium which will allow to test journey times improvements.

But in order to permit the model to run, and make the simulation definitely alive, VISSIM needs a rigorous estimation of the vehicle flows that will cross the corridor network. The transport demand, whose calculation process will be described in the next chapter of the document, will then be evaluated through origin/destination (OD) matrices based on a zonal split of the modelled network, for the two time periods of the simulation (AM and PM), and for all vehicle types except buses, as bus lines have already been entirely coded throughout this stage.

*Synthesis:*

- VISSIM, the most relevant microsimulation software for this project, a robust mathematical model that allows building the highly detailed replication the study requires.
- A meticulous building process, including numerous steps to achieve in the most thorough way, whose benefits far outweigh the consequent time-investment necessary.
- A range of inescapable limitations, which includes slightly too rough assumptions regarding traffic composition, speed intervals, and bus lines coding.
- A model that will be able to face the ultimate option testing anyway, and deliver the appropriate outputs subsequently.

# Part 4. Estimating the transport demand for the model

In this part the demand matrices calculation, indispensable to let the VISSIM model run with reality-based traffic flows across the network, will be enlightened. The procedure includes several steps whose first is the reproduction of the transport network in VISUM, the transport planning software operating along with VISSIM, through which transport demand will be estimated. Then follows the building of trips evaluation matrices (pre-matrices), that allows to progress to the final stage of the whole model building's process: the matrices calibration, and the model calibration/validation.

## *4.1. Transport network reproduction in VISUM*

This section is going to depict the creation of a VISUM version of the Birkenhead model (through the latest version of the software: VISUM 10.0), which will provide with the possibility of estimating vehicles flows. For this stage, the powerful macrosimulation tool logically appeared as the most relevant contrivance.

### 4.1.1. VISUM: a potent transport planning software

VISUM, created by the German company PTV as well as VISSIM, is part of the macrosimulators which allow to undertake urban transport planning. Unlike microsimulators, these tools don't provide with the modelling of individual users' behaviours and interactions between each other on a particular transport network, but use traffic assignment models and focus on the traffic's spreading across the network.

VISUM allows to analyze and plan a transport system which can encompass private and public transport supplies, along with travel demand. The software supports planners to develop measures and determine the impacts of these measures over the society or the environment. It includes different models which can be used to determine the effects of given transport supply: different assignment procedures able to assign current or anticipated travel demand to existing or planned transport supply, impedance matrices (matrices that follow from users' route choices, based on their costs comparisons over the various possible paths) that describe the connection quality of private or public transport supply in the network, an environmental model that makes it possible to determine noise or pollution emissions of motorized private transport, and a an operator model that determines the operational and financial requirements of public transport supply.

The tasks the macrosimulator endows with the opportunity of achieving concern either public or private transport demand. In private transport (the only category which is concerned through this stage as public transport lines have been utterly coded yet), it allows to simulate transport planning measures or construction measures to forecast resulting traffic volumes and their impacts, evaluate the effects of possible urban tolls, separate analysis of different transport systems (cars, goods vehicles, bicycles), compare origin/destination (OD) matrices with current counted data, determine noise or pollution emissions, or else generate sub-networks with corresponding partial OD matrices.

The VISUM system integrates all individual and public transport types within a single model. It is supplemented with the PTV's demand calculation programs VISEM and VISEVA, in addition to the VISSIM system which has been used so far, as part of the whole PTV's transport simulation system.

Within the scope of this stage, VISUM will be simply used for the origin/destination matrices estimation. The project does neither include impact or transport supply analyses, nor modal choice between public and private transport to be modelled, nor genuine route choices to be determined (as the network reproduced will almost systematically offer only one possible itinerary to users from origins to destinations), and the macrosimulator will finally just assist VISSIM to indicate the microsimulator how many vehicles it has to produce and attract over the different zones defined in the model (Section 3.2.10.), what types of vehicles it will be, and when they will have to be generated. In that purpose, the corridor's network has also to be built entirely in VISUM, with all relevant characteristics that will make it possible for the software to estimate realistic vehicle flows for all road segments.

### 4.1.2. Modelling the corridor in the macrosimulator

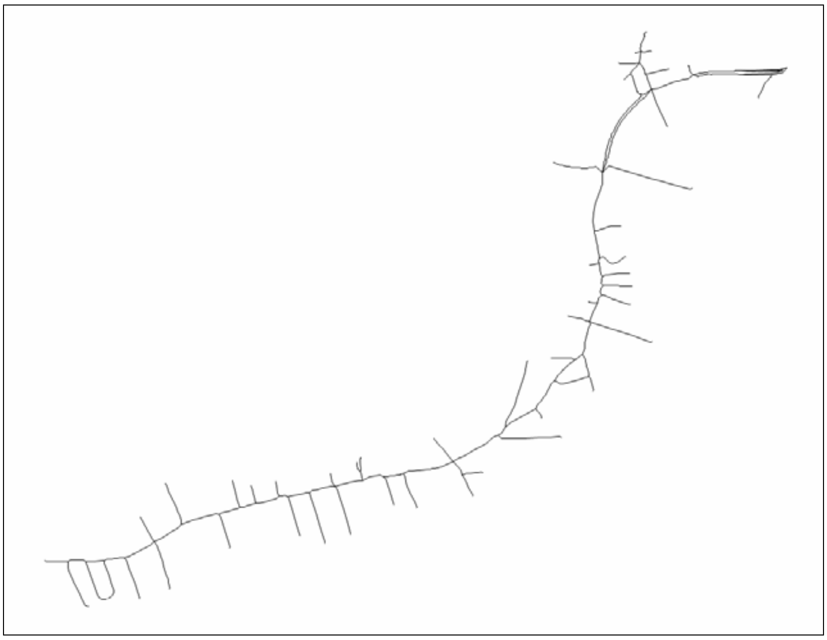
In VISUM, the network model describes the transport supply's spatial and temporal structure. For this reason, the network model consists of several objects which contain relevant data regarding links, nodes, traffic zones, public transport stops, and public transport lines with their timetables. As public transport lines are not reckoned throughout this stage, the network coding will merely include links, nodes and traffic zones, plus additional specifications concerning turns. Five transport means will be encompassed: cars, HGVs, LGVs, motorcycles and cycles. In order to fit rigorously the VISUM model to the VISSIM one (regarding links layout, nodes, zone locations and numbers), the corrdor's network was extracted from VISSIM and transferred directly in VISUM, to be displayed and refined through the macrosimulator's interface.

This section will describe the completion of the network coding by expounding its four successive steps: links characteristics coding, nodes characteristics coding, turns characteristics coding, and finally zones characteristics and zones connectors coding.

4.1.2.1. *Links characteristics coding*

As an extraction of the VISSIM network to VISUM has been proceeded, the Birkenhead corridor's VISUM model contains links shaped exactly like in VISSIM. The layout of the corridor and its access roads is then fully reproduced with the various links correctly positioned between each other, as Illustration 12 shows. The illustration evidences the network is much more coarsely represented in VISUM compared to the microsimulator: VISUM procedures are based on the network elements' characteristics far more significantly than in VISSIM where the road segment design logically plays a decisive role over the final observations.

**Illustration 12: The Birkenhead corridor network in VISUM**



*Source: VISUM illustration*

At this stage, the VISUM model is a mere "skeleton" without any parameter defined for its links. The software requires therefore coding a range of characteristics proper to every network segment, which will help calculating route choices subsequently:

- **type of the link**, this parameter being based on the real road classification over the selected network perimeter. Thus A-roads, B-roads and other outer links were specified according to their real type.
- **length of the link**, used to indicate VISUM the dimension each link is supposed to present in reality. Copied directly from the VISSIM model

through its transfer to VISUM, links lengths were integrally retained and did not have to be updated.

- **number of lanes of the link**, based on the real roads characteristics but unlike VISSIM, VISUM doesn't require the number of lanes being scrupulously respected even for the shortest links portions (flares or very short access roads). Only the number of lanes that can be observed on the majority of the infrastructures' lengths are considered within the VISUM links coding and within the vehicle flows estimation.
- **capacity of the link**, expressed in vehicles per hour (veh/h), which allows VISUM to differentiate high-absorbing roads from the narrower ones. In the model, capacities were coded according to a previous VISUM reproduction of the Birkenhead town centre area, which encompassed many of the links present in the current network. For the links newly represented in this project's model, assumptions were done to make their characteristics fit realistically to the rest of the network. Finally, coded capacities wobble between 500 veh/h for the narrowest access roads of the A552 to about 2000 veh/h for the widest segments of the corridor.
- **free flow speed (v0)**, that defines the speed at which vehicles can drive on the link when traffic conditions are perfect (*i.e.* with the minimum flow level). Also based on the preceding Birkenhead town centre model, this parameter obliged to carry out some assumptions for the new links as well, in order to set up a rigorous and consistent coding. Defined free flow speeds vary then from 20 km/h (12.4 mph) to roughly 50 km/h (31.1 mph). In VISUM, free flow speeds can't exceed the maximum speeds fixed for each user class (from about 95 km/h -59 mph- for heavy vehicles to more than 100 km/h -62.1 mph- for the lights), but in the urban context of this project individual maximum speeds are far above free flow speeds. Restrictions would be more significant over motorways, what the study doesn't include.
- **vehicle classes allowed to run on the link**, which makes it achievable, like in VISSIM, to include and exclude certain user types on the link in order to fit to the real local traffic rules. The coding of authorized and unauthorized vehicle types follows then from the real corridor's design, and is modelled on the VISSIM replication.
- **active and inactive directions**, based on the possibility to drive across the two directions of the link, or only in one direction if the segment reproduces a one-way infrastructure. This parameter obviously depends on the real roads layout, one-way roads being coded in their sole relevant direction while others include a two-directions coding.

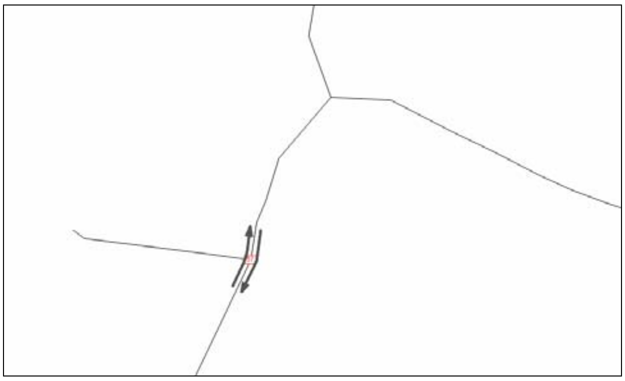
#### 4.1.2.2. *Nodes characteristics coding*

VISUM nodes are basically materialized with single points across the model, which connect links between each other. A node can join several links in the macrosimulator, but every link must be connected to only two nodes, on each of its two extremities: thus nodes actually reproduce either junctions on which two roadways or more meet, or mere unions between two different links, or else network extremities when these nodes are located on tips of the corridor's access links.

The software invites to specify coding for some parameters regarding every node. Within the scope of this matrices estimation stage, only two of them were to be set up:

- **control type over the node**, which determines how is controlled the traffic on the network element. VISUM discerns signalised controls, two-way stops (when the node is at the intersection of roads, with one flow direction having priority over another one), all-way stops (when the node is at an intersection, without priority of a particular flow direction over another one), roundabouts, and uncontrolled nodes (*e.g.* when the network object just starts or ends a link, or joins two links together). Control types of the model were logically coded according to the real traffic rules in evidence across the corridor.
- **major flow**, which allows to define traffic priorities when the node joins links with a flow direction having the right of way over another one. Modelled major flows were settled to respect rigorously real priority rules on the network. This parameter appeared very relevant to determine priorities over the numerous intersections possessing give way signals, as Illustration 13 evidences (the grey arrows symbolizing the flow direction having the right of way).

**Illustration 13: Priorities coding in VISUM**



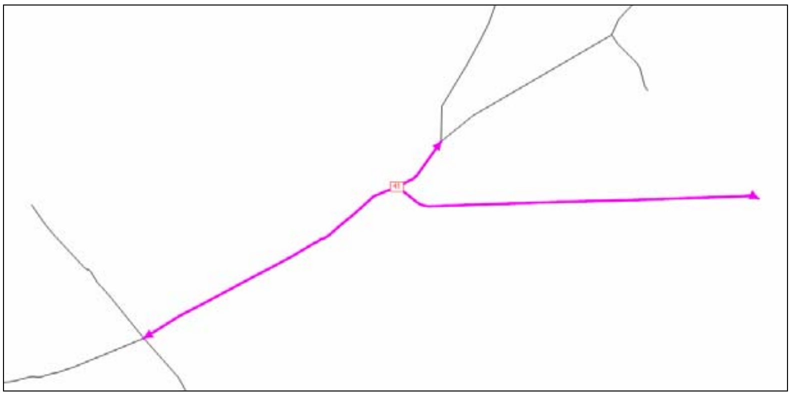
*Source: VISUM illustration*

The other prominent node characteristics, which are not to be taken into account throughout this step, are the node capacity (number of vehicles per hour the node is able to absorb) and the free flow travel time t0 (time penalty endured by users which cross the node, base on free flow traffic conditions). These parameters are not considered in the VISUM vehicle flows calculations: the only information regarding capacities have been set up in the links coding (previous section), and the values of free flow travel times over nodes will be settled through the turns coding, explained in the next section.

#### 4.1.2.3. *Turns characteristics coding*

Like in VISSIM, every new node set up in a VISUM model implies turns to be defined. In the transport planning tool, turns materialize the different route options provided to users when they approach a node (Illustration 14). Their coding has to be thoroughly achieved, as they endow VISUM with highly valuable information regarding the network's functioning.

**Illustration 14: Turns coding in VISUM**



*Source: VISUM illustration*

Three main types of parameters have to be specified for all turns possibilities:

- **authorized turns over the node**, which invites to point out the software whether a turn possibility is actually authorized in reality or not. Modelled on the real corridor's rules, turns options have been coded in such a way that they will allow to reproduce all possible traffic directions across the network. As examples, nodes located close to one-way roads will then include some turn restrictions for vehicles coming in the wrong direction, and U-turns will be banned over every junction of the corridor as this movement is not authorized within intersections in UK.
- **vehicle classes allowed to use the turn**, which provides with the opportunity to include and exclude user categories of the turn option. The coding followed then the few locations where, in the real network, a

particular vehicle type (HGVs for instance) was not supposed to be authorized or able to turn toward a particular road.

- **free flow travel time necessary to turn (t0)**, which indicates VISUM the time period lost by all users when they turn, in free flow traffic conditions, and helps the software taking into account time penalties over intersections crossings. Based on agreed values used in most of previous VISUM models, these times were coded as follows: 5 s for all left turns on the network, 4 s for all straight movements, and 7 s for all right turns.

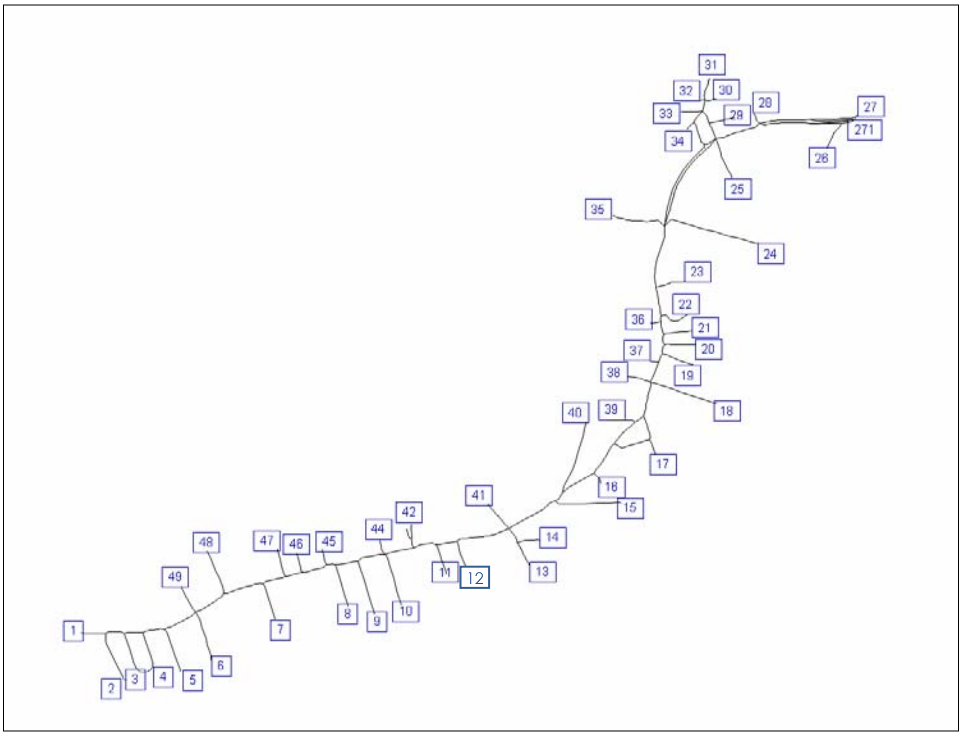
#### 4.1.2.4. *Zones characteristics and zones connectors coding*

The coding related to zones is strongly important in VISUM: the OD matrices that will be estimated through the macrosimulator will be based on the VISUM model's zonal split. As these matrices are expected to allow producing and attracting traffic in the VISSIM model zones, zone numbers and localizations must be strictly equivalent in both softwares, otherwise the microsimulation will not be allowed to run. Hence like in VISSIM, the zonal division to operate in the VISUM network will depend on its different extremities that will, one by one generate and attract traffic to and from the corridor. Each access road will then be assigned with a different zone number, the same as the one it has been given in VISSIM.

The network embraces then a total of 50 different zones. Their spatial delimitations and land use characteristics are not to be coded at this stage: assumptions will be done outside VISUM for these parameters in the next step of the process, namely the matrices creation. The macrosimulator merely requires to mark basic zone connectors, to materialize connections between individual zones and the nodes to which they are linked over the network's entries. These zone connectors will not include advanced parameters to set up (time penalties, *etc.*) as OD matrices estimation doesn't necessitate further coding. It has simply been indicated VISUM the various user types that will be allowed to leave zones and join the network: apart from a few areas over which HGVs are forbidden to run, all connectors have been opened to every user class.

Illustration 15, extracted from VISUM, permits to observe VISUM zone numbers and places match with the VISSIM ones illustrated previously (Section 3.2.10., page 59, Illustration 11).

**Illustration 15: VISUM zones over the Birkenhead corridor's network**




*Source: VISUM illustration*

The VISUM network coding being completed at this stage, the creation of trips evaluation matrices can be proceeded, including its usual steps and assumptions.

## *4.2. Creation of trips evaluation matrices*

The OD matrices creation necessitates an accurate calculation methodology. The trip distribution that will follow from this stage will indeed play a hugely important role in the relevance of the whole model: even if a VISSIM model is perfectly coded, an incorrect demand estimation set up inside this model invalidates immediately the reproduction, which can merely not be used to simulate traffic and achieve further analyses.

Considering this warning, the estimation process will be detailed precisely in this section. It will refer, at first, to the indispensable theoretical context which is supposed to guide the global calculation procedure.

### 4.2.1. Theoretical overview

The demand calculation strategy takes explicitly its inspiration from the four-step model. This model, especially intended for urban transport modelling, is the most common method to deal with issues regarding transport flows spreading over zone-divided territories. It makes it possible to encompass every transport modes the problem requires, and offers relevant outputs allowing to plan a transport supply in function of a calculated transport demand.

As its name leads to think, the model includes four successive steps before obtaining, ultimately, the desired flows estimations. These stages are: demand generation, trips distribution, modal choice, and finally route assignment. The whole process is based on a zonal split of the study area, and each of the steps can be approached with various methods depending on the data available and the final results desired.

The first stage, the demand generation, requires production and attraction totals to be determined for each zone of the area. This process allows to set the margins of the OD matrix, as follows (1, 2, 3, *etc.* being the zone numbers):

| | | **Destinations** | | | | | |
|---|---|---|---|---|---|---|---|
| | | **1** | **2** | **3** | **4** | **...** | **Total** |
| **Origins** | **1** | | | | | | w' |
| | **2** | | | | | | x' |
| | **3** | | | | | | y' |
| | **4** | | | | | | z' |
| | **...** | | | | | | … |
| | **Total** | w | x | y | z | … | |

∑

∑ Destinations

Because different types of data will be used for the demand generation estimation that is going to occur within this project, various methods will be applied: normative method (assessment of probable zone production and attraction figures based on the number of households they hold) when no trip survey will be available for the zones, or simple use of surveyed figures when official counts will allow to calculate the model's ins and outs (*e.g.* turnings counts measured over certain junctions).

The second stage, the trip distribution, is supposed to establish the number of trips that will take place from a particular zone to anther particular one. The individual matrix cells have then to be estimated in this step, through diverse possible methods. According to this project's strategy, calculations that will be achieved for the trip distribution will use the Furness algorithm through the growth factors model:

the growth factor model allows to gauge distribution vales from a base matrix (whose distribution is utterly acquainted), in a new matrix in which only production and attraction totals (demand generation) are known. And the Furness algorithm, which will be proceeded integrally through VISUM, simply applies growth factors to the original matrix's distribution figures, first to its row values (to finally match origins totals of the original matrix with the new desired values), and then to its column values (to finally match destinations totals of the original matrix with the new desired values). All growth factors are based on the division of the total origins/destinations desired values by the original matrix's ones. This method, only possible if the original matrix is pertinent and fully completed, provides with rapid estimation of the desired distribution as margins of the original and new matrix can be easily fitted. The structure of the original matrix is retained very precisely and the method is fairly simple, but it is necessary to ensure this original matrix doesn't include too many zeros as these zeros obviously can't be affected by growth factors.

The next stage of the mode is the modal choice. It includes probability calculations, based on users' generalized trip costs for each transport mode (themselves determined by journey time, values of time, trip financial costs, and other additional parameters), to determine which transport means will be used for each inter-zone trip. As mentioned this stage will not be concerned in the current project, as no modal share estimation will be achieved through the flows estimation.

The final step, the route assignment, doles out every inter-zone flow a particular itinerary on the selected network. Route choices estimation is based on rational behaviours operated by users, who are supposed to be able to calculate the generalized costs proper to each possible route for their desired trip, and ultimately choose the path whose cost is the lowest. A large range of methods allow to carry out this estimation, depending on the context of the study. Throughout this project, and as revealed previously, no significant route estimation is to be carried out: the modelled network's structure, with a mere corridor crossed by several access roads along its route, will not offer various possible paths to users for each inter-zone trip (apart from unrealistic detours), and will compel vehicles to follow the only appropriate path in each case. A route assignment procedure will be achieved in VISUM anyway (based on the different parameters settled for the network links, nodes and turns), once the pre-matrices obtained, but will simply be used for the matrices calibration afterward.

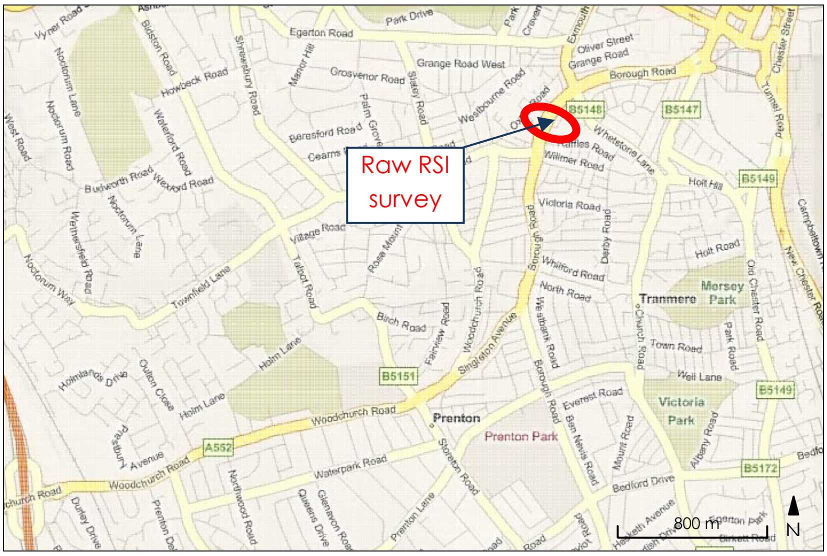
### 4.2.2. Pre-matrices estimation

The building process regarding trip evaluation matrices will follow the four-step model stages rather closely. In that purpose, the study will use its three different data available, indispensable to the procedure: the Raw RSI data 2003, the junction turning counts 2006 and 2008, and the Trics data 2008. These three sources contain real or estimated vehicle counts over the Birkenhead corridor area. As they don't have the same level of reliability (estimations including obviously more uncertainties than official surveys), they need to be used carefully and considering the most reliable information in priority throughout the calculations.

#### 4.2.2.1. *The data available*

The first source, the Raw RSI data, is a survey accomplished in 2003 by Mott MacDonald, on the Birkenhead corridor. It reckons car journeys exclusively. A group of enumerators located on a specific point of the corridor's eastern segment, between the junctions Borough Road/Whetstone Lane and Borough Road/Ball's Road East (Figure 24) stopped motorists during a typical week day and asked users information about the exact origin and destination of their trip. The survey took place over an AM and a PM period, namely 7:00 - 11:00 in the morning and 15:00 - 19:00 in the afternoon. Journeys' OD recorded during the AM period concerned outbound flows only (*i.e.* from the corridor to the Birkenhead town centre or Liverpool), whereas OD recorded during the PM period focused on inbound flows only (*i.e.* from the town centre or Liverpool to the corridor).

**Figure 24: Location of the Birkenhead Raw RSI survey 2003**



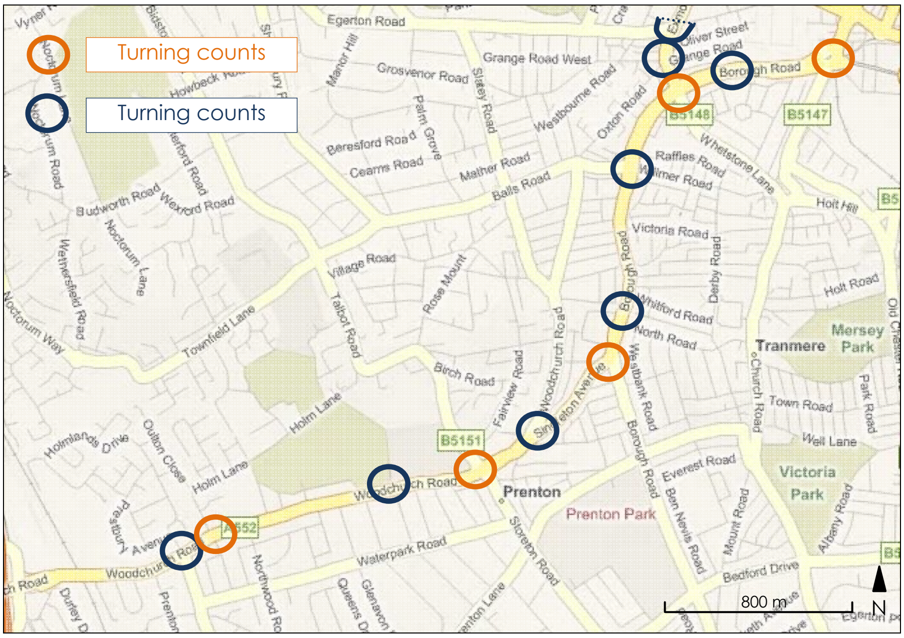

*Source: http://maps.live.com*

Thus individual origin and destination post codes (which inform fairly precisely regarding spatial localizations in UK) registered during these AM and PM time intervals were retained after the survey, and gave highly valuable data over the journey's OD on the Birkenhead corridor. Even though they regard only cars, include only a part of the real trips' OD (movements between the very eastern sector of the corridor and the rest of the network), and despite they don't cover all zones of the network, they will serve the whole flows estimation process anyway. Figures date back to 2003 but will not be modified with any factor for the current 2008-based study, to endow the project with original and very reliable values. This survey stands indeed for the most trustworthy and handy data in the matrix estimation process, and will be considered prior to the others.

The second data, in spite of the fact it is originally not supposed to inform clearly about trips origins and destinations, will be actually very useful: the junction turning counts, carried out over the eleven signalised intersections of the corridor (plus the Argyle Street/Borough Road roundabout in the east and the partial junction Exmouth Street/South Claughton Road in the north) two times in the recent years (2006 and 2008), provide with figures regarding vehicle numbers of all necessary user types (cars, HGVs, LGVs, motorcycles, cycles) in every direction of every arm encompassed in the intersections. Vehicles were numbered during an AM (7:00 - 10:00) and a PM (16:00 - 18:00) period of a typical week day. As many of the corridor's signalised junctions lead directly to network's zones, turning counts will allow to obtain consistent production and attraction values regarding these zones.

The share of surveyed junctions between the 2006 and 2008 counts is portrayed over the next Figure.

**Figure 25: Location of the Birkenhead junction turning counts 2006 and 2008**




*Source: http://maps.live.com*

As they were included in the same survey type, it was deemed 2006 and 2008 figures should be based on the same survey year. The Mott MacDonald Merseyside Information Service of Liverpool provided then with a factor to update 2006 values and match them with the 2008 counts: this factor, based on local statistics, has been fixed at 1.027 for all motorized vehicles (cars, HGVs, LGVs and motorcycles), and a lower 1.007 for cycles. It implies motorized trips across the corridor are estimated 2.7% higher in 2008 compared to 2006, whereas bike trips' increase is only 0.7%.

To end with, as Raw RSI and turning counts data still don't cover all zones of the study area, it was supposed helpful to complete them with assumptions regarding production and attraction counts for the last non-surveyed areas. These assumptions constitute the Trics data, which are solely based on the number of households counted within each zone, and liable to use the corridor. The number of households determines then flow estimations for all vehicle types, even goods transport vehicles (HGVs and LGVs), in order to simplify calculations. A trip rate per household was applied to each vehicle type (car, HGV, LGV, motorcycle, cycle), this rate varying in function of the vehicle type, the period of the day (AM or PM), and the direction of the trip (departure from a zone, or arrival to a zone). All trip rate are national values, determined after elaborate studies across UK, and already used throughout many previous Mott MacDonald projects. It is to specify HGVs and LGVs rates were settled, for this study, in such a way that they represented respectively two-thirds and one-third of the official "goods vehicles" rate (which includes both HGVs and LGVs in one figure as a rule).

The whole trip rates range ultimately used in this study is synthesised in the following table:

**Table 6: Trip rates used in the Trics data (trips/household)**

| Vehicle type | AM | AM arrival | PM | PM arrival |
|---|---|---|---|---|
| **Car** | 0.439 | 0.160 | 0.215 | 0.392 |
| **HGV** | 0.002 | 0.002 | 0.0067 | 0.0067 |
| **LGV** | 0.001 | 0.001 | 0.0033 | 0.0033 |
| **Motorcycle** | 0.003 | 0.002 | 0.001 | 0.001 |
| **Cycle** | 0.019 | 0.008 | 0.012 | 0.014 |

*Source: Mott MacDonald Integrated Transport Birmingham (2008)*

Logically, given that Trics data are based on assumptions and depend on theoretical rates, their reliability is less significant than the two other source types, which are dependable surveys. The matrices estimation process will then use, as long as possible, RSI and turning counts data, Trics estimations serving only in last resort.

#### 4.2.2.2. *The calculation process*

As stated before, OD matrices will have to be estimated for all vehicle types apart from buses: then cars, HGVs, LGVs, motorcycles and cycles will possess their own flows evaluation. And as the VISSIM model is to simulate traffic on AM (7:45 - 9:00) and PM (16:45 - 18:00) periods, with flows structures that are expected to vary markedly between pre-peak, peak, AM and PM periods, different matrices will understandably have to be created for all these different times periods. Hence a total of twenty matrices must be calculated (and will have to be all calibrated afterward), each user class having AM pre-peak (7:45 - 8:00), AM peak (8:00 - 9:00), PM pre-peak (16:45 - 17:00) and PM peak (17:00 - 18:00) matrices. In this stage, ten AM and PM peak pre-matrices will be estimated, whereas the ten pre-peak matrices will obtained intuitively through the calibration process depicted in the next section.

According to this project's strategy, the evaluation matrices calculation will rest mainly on one transport mode amid the others: cars. As the most relevant and reliable data for the process, the Raw RSI survey, are exclusively based on car trips, the demand estimation method will focus on car users primarily. A pre-matrix will then be obtained for car flows in a first time, for the AM peak period initially as this time interval is expected to include more surveyed trips in the calculation and make the resulting matrix more consistent. And to avoid repeating the long calculation process in its entirety for the nine following pre-matrices, the AM peak car trips distribution finally determined will be used as a base for all other ensuing calculations.

The Raw RSI data already contain very precious information: it allows to find out a primary trips distribution for car journeys. But as this source is restricted to only one survey location at the very east of the network (taking into account only outbound flows which go toward the eastern exit of the corridor, and inbound flows that come from the infrastructure's eastern extremity), the resulting distribution is far from being complete: no OD flows between western zones could be recorded, which obviously makes the distribution only partial. Many individual OD are not observable in the survey results, many particular zones are simply absent of the counts, and if used such as it is currently, the car trips distribution would lead to a matrix embracing far too many zeros. A high number of zeros in the distribution could then distort subsequent calculations using the car pre-matrix as a base. The importance level of this stage doesn't allow to consider incomplete estimations, that is why both of the other count data (turning counts and Trics) will have to be used as a complement in the process: the objective is then, one the one hand, to determine the car pre-matrix's margins (demand generation for cars only) through the three sources of information available, and then, on the other hand, use the RSI data original distribution to carry out a projection targeted toward these desired margins, thanks to a Furness algorithm. The outcome will therefore be the desired AM peak car pre-matrix.

To resolve the problem of the many zeros present in the RSI original distribution, which would make the Furness calculations impossible, a unitary matrix will be introduced in this distribution, added to the existing surveyed values. The concept is illustrated as follows:

**Raw RSI distribution**

| | | Destinations | | | | | |
|---|---|---|---|---|---|---|---|
| | | **1** | **2** | **3** | **4** | **…** | **Total** |
| **Origins** | **1** | | 0 | a | 0 | 0 | w' |
| | **2** | b | | 0 | c | 0 | x' |
| | **3** | 0 | 0 | | d | 0 | y' |
| | **4** | 0 | e | f | | 0 | z' |
| | **…** | 0 | 0 | 0 | 0 | | … |
| | **Total** | w | x | y | z | … | |

**+**

**Unitary matrix**

| | | Destinations | | | | | |
|---|---|---|---|---|---|---|---|
| | | **1** | **2** | **3** | **4** | **…** | **Total** |
| **Origins** | **1** | | 1 | 1 | 1 | 1 | 49 |
| | **2** | 1 | | 1 | 1 | 1 | 49 |
| | **3** | 1 | 1 | | 1 | 1 | 49 |
| | **4** | 1 | 1 | 1 | | 1 | 49 |
| | **…** | 1 | 1 | 1 | 1 | | … |
| | **Total** | 49 | 49 | 49 | 49 | … | |

=

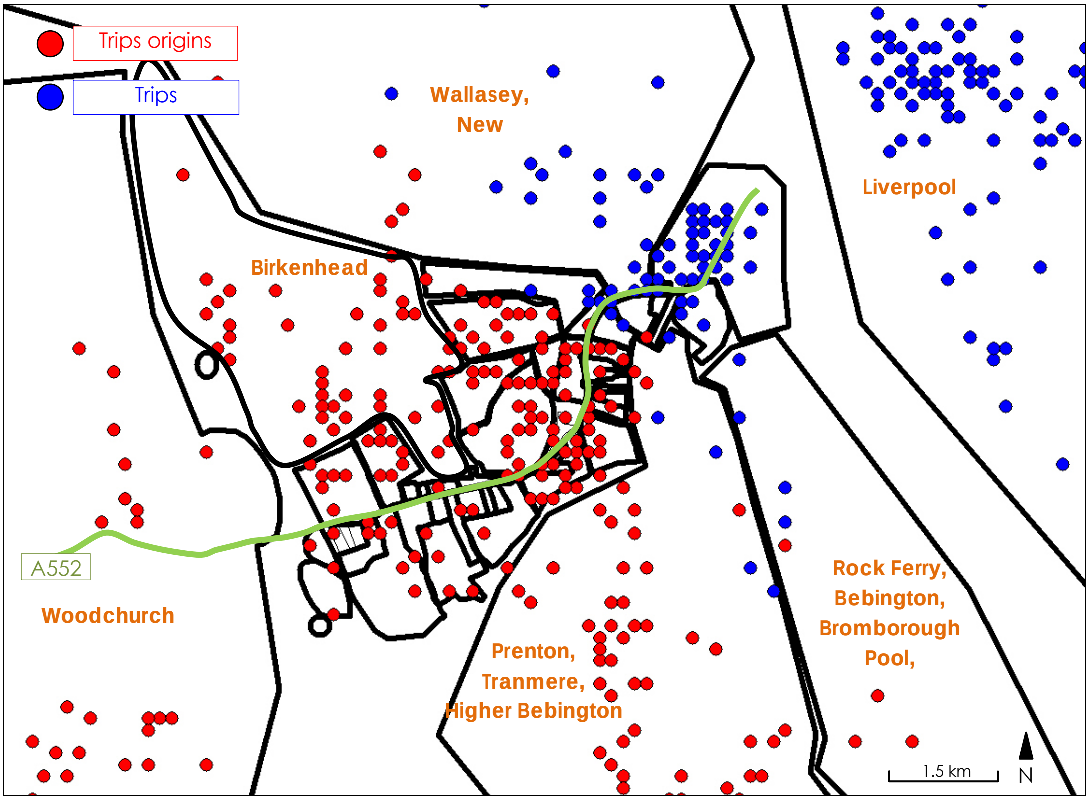
**Updated distribution usable for the Furness**

| | | Destinations | | | | | |
|---|---|---|---|---|---|---|---|
| | | **1** | **2** | **3** | **4** | **…** | **Total** |
| **Origins** | **1** | | 1 | 1+a | 1 | 1 | 49+w |
| | **2** | 1+b | | 1 | 1+c | 1 | 49+x' |
| | **3** | 1 | 1 | | 1+d | 1 | 49+y' |
| | **4** | 1 | 1+e | 1+f | | 1 | 49+z' |
| | **…** | 1 | 1 | 1 | 1 | | … |
| | **Total** | 49+w | 49+x | 49+y | 49+z | … | |

The first calculation step reckons then demand generation for cars, in the AM peak period: the pre-matrix's margins are to be settled based on the three sources of counts available. Turning counts and Trics figures contain initially production and attraction information in the relevant format: zones origins and destinations are already know for several zones and can be used in a raw state. But as far as the Raw RSI data is concerned, the origins and destinations postcodes that emerged from the survey are evidently not classified according to this study's zonal delimitation. Thus the prior task is to include all trips information from these data in the zonal split which is current in VISSIM and VISUM.

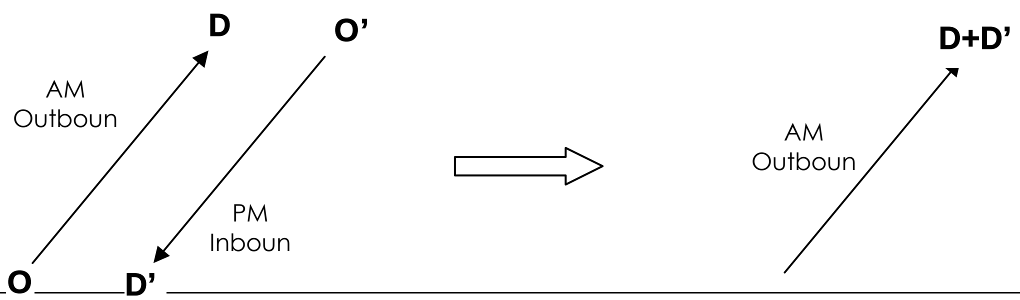
The MapInfo software is the most relevant tool for this kind of chore. At first, zones were drawn in the software, in a higher number than in the simulators, as surveyed trips frequently originate or end in fairly far locations from the corridor. The MapInfo zonal split, considering a much larger territorial space than the VISSIM and VISUM ones, has been carried out in gathering households locations which have been supposed to use the corridor for their journeys in the same way: that means house localizations embraced in the same zone are expected to enter and leave the corridor thanks to the same access road (*i.e.* by the same VISSIM and VISUM virtual zone). The following figure (Figure 26) shows how this zonal division has been achieved, and includes the example of the AM outbound trips' origins (red spots) and destinations (blue spots) in particular.

**Figure 26: Gathering of AM outbound trips' origins and destinations in the MapInfo zonal division**




*Source: Raw RSI data (2003), MapInfo illustration*

A similar maps was created with this method for the PM inbound trips' origins and destinations (Appendix 16, page 113). PM counts will indeed be appended to the AM ones in this stage, to enhance the total number of trips surveyed and make the AM data more consistent. For that, a simple addition of the PM inbound trips' origins to the AM outbound trips' origins, and of the PM inbound trips' destinations to the AM outbound trips' destinations is to be done: assuming PM the trip distribution is equivalent to the AM one reversed, PM inbound origins can effectively be considered alike AM outbound origins, resulting in a more important AM database as the following diagram shows (O and D being respectively origins and destinations):



O+O’

In that way, all information from the Raw RSI data can be collected in only one OD distribution for the AM period. It is to point out the building of these data took in the surveyed counts for all the survey period (7:00 - 11:00 and 15:00 - 19:00): this procedure was necessary as the number of trips counted in the desired AM peak period (8:00 - 9:00) was considered insufficient to make a consistent trips estimation.

To end with the shaping of this Raw RSI data, assumptions were done as part of the conversion of MapInfo zones into VISSIM and VISUM zones: as productions and attractions information following from the RSI data must fit to the modelled zones, these information needed to be classified rigorously according to the simulators’ zonal split. Thus the additional zones drawn in MapInfo, not considered in VISSIM or VISUM and used especially in the geographical information system to deal properly with the various OD counts, were merged with the most relevant simulation zones. Merges were decided by suppositions over which simulation zone, located in the proximity of the additional MapInfo zone to remove, could match the most pertinently with the way households of this MapInfo zone use the corridor (*i.e.* additional MapInfo zones were assigned with the VISSIM/VISUM zone number corresponding to the access road users are supposed to choose when they enter and leave the corridor).

From this point all of the three count data possess their proper origin and destination figures, corresponding to the same zonal division, with the same zone numbers. Their only difference remains the time period from which counts are extracted: turning counts and Trics information allowed to provide with figures concerning the desired 8:00 - 9:00 AM peak period, when RSI data compiled trips from 7:00 to 11:00 and from 15:00 to 19:00. Following calculations reckoning demand generation will not mind this difference, the RSI survey being the most reliable source of information, having priority over the others, and its values being indispensable to the rest of the process.

The demand generation for AM peak car trips is then allowed to be concluded, by a mere addition of all productions and attractions totals indicated in the three counts data (this addition of all journeys originating and ending in each individual zone giving the origin and destination values for the 50 areas). The margins of the desired trips distribution matrix become therefore known and accepted, and stand for target values in the trips distribution stage.

This trips distribution is basically achieved through a matrix projection, operated thanks to the Furness algorithm, from the incomplete AM distribution outline created with the RSI data, and based on the desired matrix’s margins obtained in the generation step. As pointed out previously, using the RSI distribution in a raw state for the Furness calculations would distort strongly reality and make results incorrect, as the distribution outline includes a lot of zeros. That is why using an unitary matrix is indispensable in this stage: this unitary matrix is to be appended to the original RSI distribution, by a simple matrix addition, in order to replace all empty OD with figures that allow to be transformed through the Furness successive calculations.

The projection of the updated RSI distribution to the desired target values was then proceeded through VISUM, which made it possible to attain rapidly the target margins once growth factors had been indicated to the software. As a result, the relevant 50×50 AM peak car pre-matrix was obtained, and could be used to accelerate the subsequent calculations consequently.

For the four other matrices reckoning the AM peak period (HGVs, LGVs, motorcycles, cycles) indeed, the trips distribution calculated for cars was preserved scrupulously. A Furness algorithm was applied to each of them, based on their proper target margins obtained from the turning counts and Trics data only (as no information regarding these modes was available in the RSI survey). As a result of this procedure all AM peak pre-matrices were estimated.

Then the calculation of PM peak matrices was undertaken: according to the hypothesis PM trips distribution was equal to the AM one reversed, the final AM peak car pre-matrix distribution (the one including the most OD figures) was basically transposed, all AM origins becoming PM destinations and all AM destinations becoming PM origins. Concerning zones accessing the corridor through one-way roads in the morning, assumptions were achieved to turn away originating or arriving vehicles toward relevant close zones in the afternoon, that were supposed to generate or attract vehicles the most likely instead of the AM zones. A new PM peak base distribution thus acquired, projections could then be proceeded for all vehicle types, based on desired margins obtained from turning counts and Trics data related to the PM peak period (17:00 - 18:00). The Furness algorithm allowed again to carry out the calculations, resulting in five final PM peak pre-matrix for cars, HGVs, LGVs, motorcycles and cycles. The ten peak hour pre-matrices were then estimated from the RSI base distribution.

These last calculations allowed to have finally all desired pre-matrices at disposal: five were estimated for the AM peak period (one par vehicle class), and five for the PM peak. But these matrices are still not definitely the ones which will be used for the model simulation: they all have to be calibrated, both in VISUM and VISSIM, in order to be trustfully used in the VISSIM model afterward, which requires a rigorous reproduction of the real flows.

## *4.3. Calibration of the pre-matrices, and calibration/validation of the VISSIM model*

The calibration and validation procedures are the ultimate stages of the whole model building. They are thoroughly indispensable as the demand matrices estimation which has been carried out in the previous steps, despite its rigorous process, doesn't guarantee VISUM and VISSIM will assign flows exactly like reality (reality being mirrored by the official surveys available). To make the model utterly valid for subsequent testing, it is to ensure and confirm all estimated flows are spread in the network by respecting observed counts.

The process includes at first the pre-matrices calibration in VISUM, operated with the help of the software's route assignment procedure, which allows to bring definite matrices in the VISSIM model. Then follow the very last stages, the VISSIM model's calibration and validation, carried out through simulation tests using the estimated demand.

### 4.3.1. Pre-matrices calibration in VISUM

Trips evaluation matrices were mainly estimated outside VISUM, the macrosimulator helping merely to operate Furness algorithms for the projections. On the contrary the software will play a central role in the calibration stage, through its capacity to simulate traffic spreading within the network. VISUM possesses indeed an elaborate route assignment system that makes it possible to model path choices across road infrastructures from an estimated demand matrix. For that, the software takes into account all coded parameters regarding the network's structure (links types, links capacities, node control type, authorized turns, *etc.*) and includes users' impedance values in the calculations: value of time, value of distance, *etc.* (for which advanced coding were not necessary in this project as they haven't the least influence on the itineraries assignment). Even though users route choices are known in advance it this study, the VISUM assignment procedure will be very useful as it will allow to observe the number of modelled vehicles present on every link of the VISUM-modelled network: these modelled flows will then be collated with the surveyed ones in order to proceed to the calibration.

The pre-matrices calibration consists in adjusting their OD figures to bring resulting virtual flows to the official counts observed on road segments. The purpose is clearly to reproduce traffic diffusion on the model of the real situation. For that, observed flows on the real Birkenhead network's road segments will be compared with the modelled flows on the same segments. The matrices' validity will then be evaluated through the Geoffrey E. Havers's widespread indicator: the GEH. This indicator takes into account observed and modelled flows across segments of a network, within the following formula:

$$GEH = \sqrt{\frac{(O-M)^2}{\frac{(O+M)}{2}}}$$

where: O is the vehicle flow observed on the real road segment
M is the vehicle flow modelled virtually on the same road segment

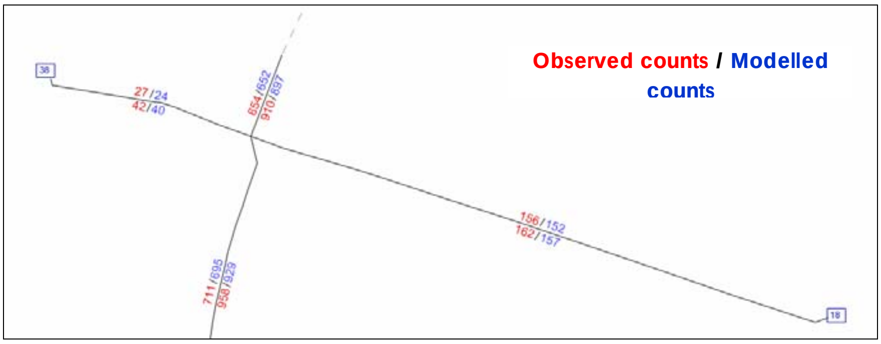
The result, the GEH, provides with indication over the reliability of the model: the lower the GEH is, the more reliable and realistic the model is. A GEH smaller than 5 is then recommended to ensure the traffic replication is faithful enough to reality. Using this indicator as an acceptance criterion within the scope of travel demand forecasting models is recognized in the UK Highways Agency's Design Manual for Roads and Bridges (DMRB), which states a model should encompass at least 85% of GEH lower than 5 to be valid.

In this stage, the objective is to reach 100% of GEH lower than 5. It is to remind matrices calibrated at the end of this step will have to be calibrated again in VISSIM afterward: if the VISUM calibration led to insufficiently consistent matrices, the following VISSIM calibration would be even more complicated and would threat the whole model's validity.

For the calibration of the ten matrices previously estimated, flow comparisons will actually not concern the totality of the network's roads. Only a panel of road segments, for which very reliable vehicle counts are available, will be used. These particular roads will be the ones included in the 2008 junction turning counts survey: observations recorded in these data are the most appropriate, the most recent and the most reliable for the purpose of this stage. Figure 25 (Section 4.2.2.1., page 75) has previously illustrated the network's junctions surveyed in 2008. All subsequent GEH evaluations will hence solely concern roads observed around these seven junctions (plus the partial intersection in the north), that is 26 segments comprising a total of 52 individual counts are to be compared. There would be no point using the Trics data, which is not based on official observations, or the RSI data, which is too old and doesn't provide with the desired information anyway. Even the 2006 turning counts have been deemed not recent enough for such an important process.

Once the route assignment procedure is carried out in VISUM, observed and modelled vehicle counts can be conspicuously collated in the software's network, as Illustration 16 evidences.

**Illustration 16: Observed and modelled counts collation in VISUM**




*Source: VISUM illustration*

The calibration procedure starts then at this point: GEH can be calculated, for each of the ten trips estimations, from counts information relative to all relevant road sections, and lead to primary results regarding the demand estimation's reliability. If 100% of the GEH proper to a particular route assignment are already below 5 after this first evaluation, the matrix corresponding is already calibrated and can be used such as it is for the subsequent VISSIM calibration. But none of the trips evaluation matrices entailed the desired perfect GEH immediately: the proportion of accepted reliability indicators fluctuated actually from 60% for the most critical estimations, to 90% for the best.

In this case, the VISUM TFlow-Fuzzy procedure proves indispensable: the macrosimulator operates an automatic matrix correction, in an attempt to match modelled flows with the observed ones. The TFlow Fuzzy uses desired flows (observed counts) as target values and brings modelled ones as close as possible to these target values, through a hundred of iterations. After this automatic correction, which has been repeated as long as necessary until a maximum of GEH became below 5, most of the ten pre-matrices showed 100% of acceptable GEH and were then calibrated.

For the others, notably the AM peak cars, AM peak motorcycles and PM peak LGVs, further adjustments were to be done. A TFlow-Fuzzy prevented from reaching 100% of valid GEH implied some manual corrections were to be undertaken within the pre-matrices: this procedure consisted primarily in transferring the OD values which prompted unrealistic differences between observed and modelled flows, to other relevant OD which didn't affect GEH. Obviously these transfers had to be carried out in respecting the supposed trips origins and destinations as much as possible, no OD could be removed from an extremity of the network and added to the opposite extremity without clear relationships between the zones concerned. The matrices were then calibrated manually, according to a range of argued assumptions to finally bring their GEH proportion to 100% and make them valid for the following procedures.

Before being wholly usable for the VISSIM calibration, all VISUM-calibrated matrices had to undergo two last modifications. At first, their OD needed to be rounded off as the successive calculations operated on each matrix (projections with growth factors and TFlow-Fuzzy corrections) transformed their natural values into real numbers and prompted the appearance of decimals. A demand estimation whose OD contain decimals is not acceptable as a quantity of trips is necessarily a natural number on the one hand, and because VISSIM requires natural values to understand how many vehicles it has to generate in the network on the other hand. A mere excel macro allowed then to proceed to the desired adjustments and brought back realistic and valid matrices.

The last alterations concerned the traffic spreading's relevance. It had to be specially ensured the VISUM route assignment proper to each matrix didn't show exaggeratedly high vehicle volumes on the smallest corridor's access roads: not only unfitted volumes mirror a distortion of reality and an imperfect demand estimation, but they also stand for a threat to the ensuing VISSIM model's implementation by producing unexpected and undesired queues. This checking was only carried out for the two car matrices (AM and PM), since these were the only estimations containing a consequent number of trips (near 8,000 journeys within each of the two peak hours), and liable to give unrealistic flow dispersals. Adjustments were operated on the model of the manual calibration described further back, that is by transferring trips' OD from zones containing unrealistic estimations to close zones, possessing access roads with higher capacities, and likely to produce and attract traffic instead of the misestimated ones. Both car matrices have then been slightly modified to lastly entail the desired results.

All peak hour matrices being ultimately calibrated at this stage (see the sundry ranges of GEH for AM and PM in Appendices 17 and 18, pages 114 and 115), pre-peak matrices could be deducted from them by simple calculation: a relevant factor was merely to be applied to each figure of the different peak matrices to convert them into pre-peak ones. This factor was different for each user class and for each time period (AM and PM), it had been calculated from the latest and most reliable turning counts data (2008 exclusively) through the division of all vehicles of a particular class counted over peak periods (8:00 - 9:00 and 17:00 - 18:00) by those of the same class counted over pre-peak periods (7:45 - 8:00 and 16:45 - 17:00). The formula is the following:

$$\text{Pre-peak factor} = \frac{\sum_{i=1}^{n} PkC}{\sum_{i=1}^{n} pkC}$$

where: n is the number of roads for which a turning count is available in the 2008 survey,

PkC is the number of vehicles counted during the defined AM or PM peak hour,

pkC is the number of vehicles counted during the defined AM or PM pre-peak hour.

The following table illustrates the individual pre-peak factors obtained for all necessary estimations. As evidenced, all of these factors are smaller than one: this result was obviously expected as traffic during pre-peak periods is less important than in peak hours.

**Table 7: Calculation of pre-peak factors for pre-peak matrices**

| Vehicle type | Total vehicles AM pre-peak (observed) | Total vehicles AM peak (observed) | Conversion factor AM: (pre-peak/peak) | Total vehicles PM pre-peak (observed) | Total vehicles PM peak (observed) | Conversion factor PM: (pre-peak/peak) |
|---|---|---|---|---|---|---|
| Cars | 4996 | 25278 | 0,20 | 6990 | 28170 | 0,25 |
| HGVs | 127 | 641 | 0,20 | 80 | 249 | 0,32 |
| LGVs | 820 | 3191 | 0,26 | 621 | 2095 | 0,30 |
| Motorcycles | 70 | 209 | 0,33 | 94 | 274 | 0,34 |
| Cycles | 42 | 62 | 0,68 | 41 | 117 | 0,35 |

*Source: Excel calculation*

These calculations concluded the primary demand estimation procedure and its observation in VISUM. All matrices determined so far can finally be tested in the network replication which has been waiting for them: the VISSIM model.

### 4.3.1. Calibration/validation of the VISSIM model

The VISSIM model calibration and validation are the ultimate procedures of the model building. In this stage, the demand previously estimated and calibrated for each user class separately has to be introduced in the microsimulation model, allowing the reproduction to run including all desired vehicle classes for the first time (cars, buses, HGVs, LHVs, motorcycles, cycles), and the inescapable adjustments to be achieved.

Like VISUM, the microsimulator possesses its own route assignment procedure: depending on the various parameters coded for every VISSIM network element (desired speeds, reduced speed areas, road lengths and widths, *etc.*), the software allocates a particular path to each vehicle allowing all users to reach their destinations with minimum generalized costs expected. A first simulation of the model, generating vehicles of all user classes together and allowing them to move without any traffic controls (neither priority rules, nor signal heads), permits VISSIM to determine these individual paths, and save them in a specific file usable for all following procedures. Hence every simulation that will be carried out afterward will use the original path file constantly, and individual vehicle routes will never change.

Any traffic testing and analyses are indeed non-valid if they have been based on a simulation over which vehicle were searching for new paths: testing results can't be studied pertinently if it remains impossible to distinguish traffic evolutions that are due to network improvements from those that follow from new paths researches.

Once path files are obtained for the two simulation periods of the model (AM and PM), both calibration and validation can be proceeded with the fixed route assignments: these final tests are intended to ensure the VISSIM model's traffic simulation is sufficiently reliable, and can be used trustfully for the subsequent options testing and advanced analyses. The calibration still regards vehicle counts which are required, in the microsimulation, to be as close as possible to the real ones. As for the validation, the process will be aimed at fitting modelled travel times to the observed ones. Achieving these tests is possible through a first simulation of the model over AM and PM modelled periods, relevant data (vehicle flows and journey times) being recorded by the data collection points previously settled in the software (Section 3.2.11., page 59).

Following the miscellaneous vehicle flows adjustments already operated in the preceding stage, the calibration is a familiar process at this stage: based on the same panel of junctions as the previous VISUM comparisons (2008 counts only), the VISSIM calibration is targeted at evidencing the model is able to cope conveniently with the traffic volumes it generates. The objective remains to match modelled and observed flows counted over the same time period (still peak hours exclusively in this case), through a proportion of acceptable GEH at least equal to 85% (following national recommendations) for cars, HGVs, LGVs, motorcycles and cycles. Reputed more intricate in VISSIM than in VISUM, the calibration carried out with the microsimulator proved effectively certain manual adjustments were to be done in both AM and PM models: several zones could not generate the total number of vehicles they had to produce because of queues stretched outside the network limits, some of the signal heads didn't allow to evacuate traffic enough as their green times were too low for the major flows, a few road connectors appeared misplaced or miscoded and didn't prompt fluid moves, and a few vehicles used unrealistic itineraries by making slight detours. As VISSIM removes from the network vehicles that are stuck in the traffic more than 60 simulated seconds, many modelled counts were finally missing and entailed an insufficient reliability for the model when compared to the surveyed counts.

These observations implied several modifications to be undertaken in the model, in an attempt to overtake the minimum acceptance level. Thus the most congested VISSIM road segments were extended to allow the model generating traffic from further distance and then assign more vehicles (Illustration 17). This adjustment helped modelled counts to increase significantly and improved the diverse GEH. In addition, certain green times were made longer for major flows on junctions crossed by high vehicle volumes, several road connectors were altered (by adjusting lane changing starts and emergency stops), shifted or added on the approach of the most congested intersections, and unrealistic detours were precluded through particular paths closures.

**Illustration 17: Road segment extension enhancing the traffic that enters the VISSIM network**


*Source: VISSIM illustration*

These different changes have ultimately brought the model to a high standard of reliability regarding vehicle flows, as accepted GEH proportions for the five vehicle types and for both time periods are finally equal to 100% (Appendices 19 and 20, pages 116 and 117). With matrices calibrated at 100% of accepted GEH in VISUM, and a VISSIM model also calibrated at 100%, it seems subsequent testing can be trustfully accomplished.

As far as the validation is concerned, the comparison between observed and modelled travel times starts after a simulation recording these times on the same checkpoints of the network is implemented. Data collection points allowing to obtain these information have been coded the relevant way in the VISSIM model building (Section 3.2.11., Figure 23, page 61), and journey times results will be collated with official measures carried out by the Mott MacDonald Merseyside Information Service (MIS) over the same checkpoints. The MIS survey includes a set of various travel times observed over two different periods of a representative week day (7:00 - 9:00 and 15:00 - 18:30, allowing to take into account pre-peak and peak periods), with a dozen of measures for each period. Like the calibration, the validation coerces to validate both AM and PM models.

In the validation process, the data collation is proceeded through two main values, the first regarding modelled times (obtained for the simulated peak hour period) and the second concerning surveyed times (measured during the same peak hour period): the sum of all average travel times modelled over the different sections of the network (A) on the one hand (bringing a single value for the model estimation), and the sum of all average travel times observed over the different sections of the network (B) on the other hand (bringing a single value for the surveyed measures). To validate the model, three particular conditions require to be confirmed. At first, the model's travel times sum must be within boundary of the survey's travel times sum plus/minus 95% of the different surveyed values' standard deviation:

$$B - (0.95 \times StDev(S_1,..,S_n)) \leq A \leq B + (0.95 \times StDev(S_1,..,S_n))$$

where: A is the sum of all average modelled travel times,
B is the sum of all average surveyed travel times,
$S_1,..,S_n$ are average surveyed travel times successively observed in the survey.

Secondly, the model's travel times sum must be within limits of the survey's travel times sum plus/minus 15% of this survey's travel times sum:

$$B - (0.15 \times B) \leq A \leq B + (0.15 \times B)$$

where A and B still respectively correspond to the modelled and surveyed sum of all average travel times.

Thirdly, the model's travel times sum must be within limits of the survey's travel times sum plus/minus 1 minute:

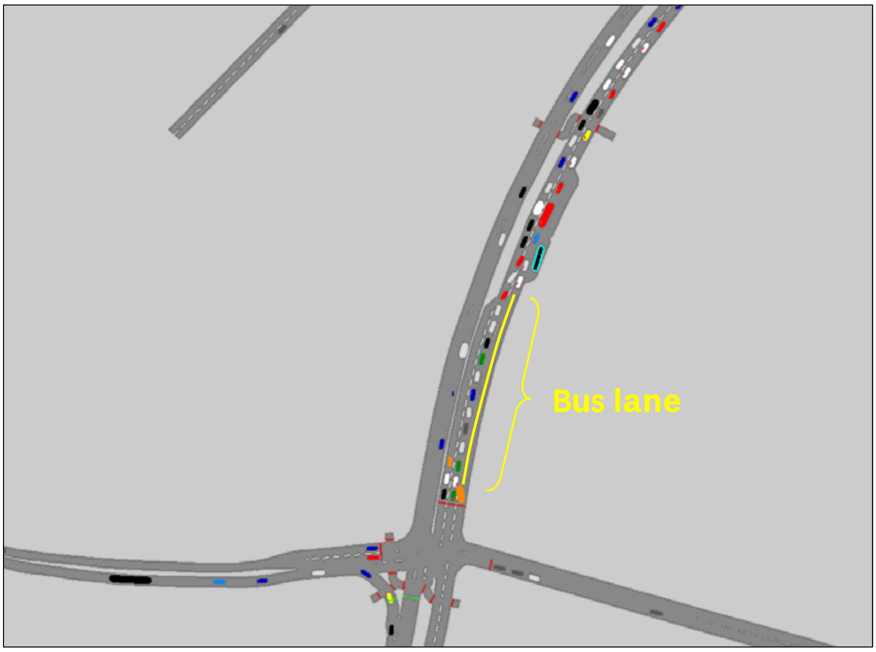
$$B - 1 \text{ min} \leq A \leq B + 1 \text{ min}$$

where A and B still respectively correspond to the modelled and surveyed sum of all average travel times.

Even though partial travel times modelled on certain individual sections of the network may not confirm one of these three conditions, the model is validated anyway if the sum of all its average journey times remains within the required limits. In this case, the number of invalid sections must not be too significant otherwise the actual relevance of the replication can be called into question. It will be especially ensured modelled times remain globally lower than the maximum surveyed values, and higher than the minimum ones.

Comparisons of observed and modelled data proved fairly useful for both AM and PM models: the two simulation periods showed initial travel times markedly high, contrasting excessively with surveyed measures and bringing the models outside mandatory limits. It appeared virtual congestion had been made too important, vehicles could not reach their destinations in realistic time periods and the model, if used in a raw state, would not have been relevant for testing and analyses. Illustration 18 shows a typical case in which traffic jams were exaggerated. In the network's section portrayed, all vehicles running on the left lane (south bound) had to shift toward the right side as a bus lane (highlighted in yellow) substitutes for the private vehicles' one, while certain vehicles placed on this right lane and planning to turn right at the next intersection also changed lane to use the additional flare. This entailed the occurrence of many merges on the road and made the traffic rather jerky.

**Illustration 18: Exaggerated congestion located through the validation process**



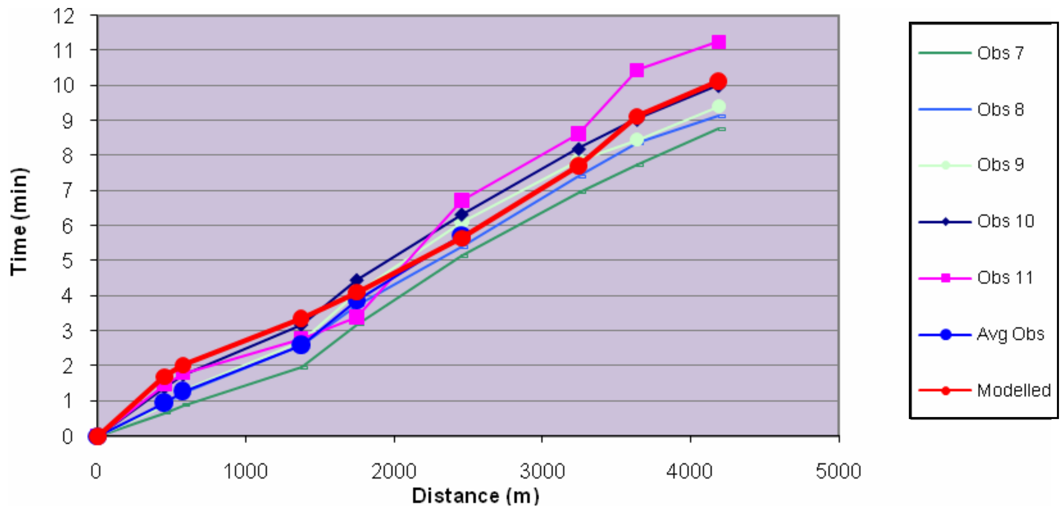

*Source: VISSIM illustration*

Following from this kind of observations, slight updates reckoning the coding of the models' network elements were then achieved, in an attempt to replicate more rational driving behaviours and bring modelled travel times down. A few new connectors were then to be altered or added again to control lane changes in a better way, and above all, coded speeds (desired speed decisions and reduced speed areas) were to be faintly enhanced over several particular locations of the network (*e.g.* the very eastern portion of the corridor, where the exit of the Mersey

Tunnel and the Argyle Street/Borough Road roundabout merge and create consequent queues).

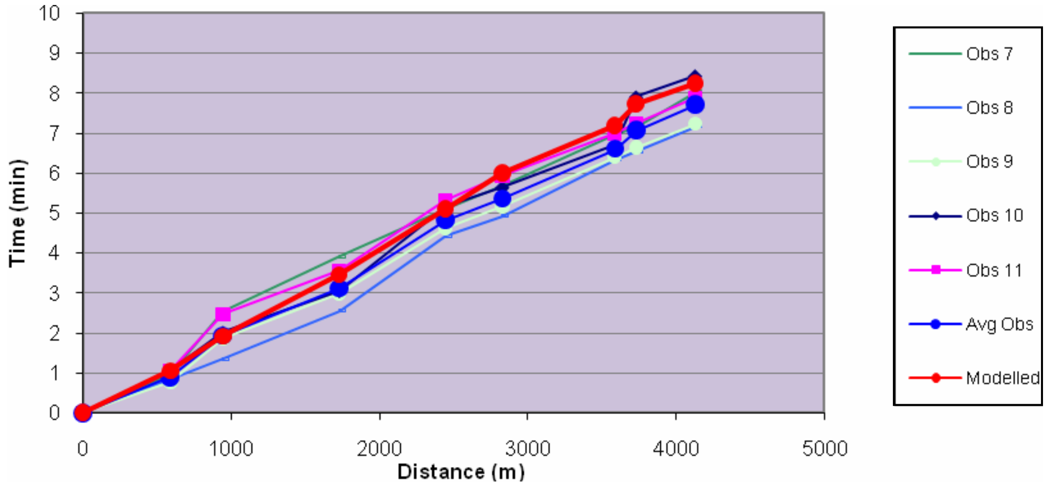
These combinations of updated connectors and increased speeds have finally brought the VISSIM model within travel times limits, and have led to globally satisfying results regarding traffic reproduction. Both AM and PM simulations are therefore validated, with their modelled journey times respecting the three indispensable conditions (Appendices 21 to 26, pages 118 to 123). Figure 27 and 28 evidence an example of the virtual travel times' conspicuous reliability, by illustrating with the relation between travel times and distances for the AM north and south bounds (equivalent figures regarding PM can be seen in Appendix 27, page 124). Notwithstanding higher south bound journey times, which appear close the maximum surveyed measures, both traffic directions include times situated in the relevant range of values (*i.e.* lower than maximum observations, and higher than the minimum ones).

**Figure 27: Comparison of modelled and observed travel times across the corridor (AM period, north bound)**




*Source: Excel calculation*

**Figure 28: Comparison of modelled and observed travel times across the corridor (AM period, south bound)**




*Source: Excel calculation*

This validation was the last adjustment to operate on the model, which is then definitely calibrated, validated, and henceforth entirely usable for the subsequent testing that will be undertaken. It appears nonetheless relevant to point the main limitations that arose throughout the entire demand estimation process.

## 4.4. Limitations of the process

The depiction of the entire demand estimation methodology has inescapably shown a range of inconveniences, which need to be summed up in order to consider the final model with sufficient distance for the forthcoming tests and analyses. Although numerous cautions accompanied the procedure, miscellaneous weaknesses appeared indeed both through the matrices estimation and calibration/validation stages.

Regarding matrices calculations, shortcomings concern the data on which the full estimation process was based, not only over the data themselves but also over the way they have been used throughout the successive steps. These limitations were most of the time clearly notable through the method's description. Thus, the Raw RSI data, primary source of information for the demand estimation, that provided with a trips distribution allowing to determine the twenty desired matrices directly or indirectly, proved to include indisputable inconveniences: the survey concerns only cars journeys when the project requires estimations for every user type (which involved assumptions that trips distribution were equivalent for each vehicle class), its figures date back to 2003 without application of a factor supposed to take into account trips rates' evolution in time, and its results are restricted to the sole survey point located on the eastern part of the corridor (giving precious information related to inbound and outbound travels, but ignoring other OD possibilities). Moreover, in the demand generation step, it has been specified all RSI data's values had been taken into account in the calculation whatever the survey time, whereas counts from the other data had been strictly restricted to the defined AM peak hour:

not only the final generation compiled values obtained from various time periods, but the final distribution also included trips' OD recorded outside this peak hour.

As far as turning counts surveys were concerned, if their figures were consistently obtained from recent observations and obviously didn't question the demand estimation's relevance, the fact a conversion factor was necessary to have 2006 and 2008 values at disposal (both for the demand generation and for the diverse target values projections required) implied automatically the appearance of uncertainties through the calculations. The two defined growth factors seemed pertinent regarding Wirral's global traffic growth, but it was acknowledged the motorized vehicles' growth factor didn't consider growth variations between the different motorized modes: car trips surge may probably be higher than 2.7%, whereas other vehicle types' one may be below this value.

The last sources of information, the Trics data, are certainly the one embracing the most limitations: as mentioned, Trics counts had been estimated from subjective assumptions over a number of households comprised in a particular area, to which defined trip rates were applied. These assumptions can evidently not be utterly reliable, they were simply based on supposed probabilities for the households to use the corridor, and can prove significantly different in reality. Moreover, basing even goods vehicles flows estimations (HGVs and LGVs) on the number of households present in the areas, instead of considering other factors for these particular vehicle types (presence of commercial or industrial areas), is also a clear inconvenience. The other main issue regarding these data is their trip rates: merely based on national statistics, they don't mirror local reality and imply all households have the same travelling behaviours. Better still, the modal share following from the rates applied to the various user types appeared frequently in contradiction with the official turning counts surveys: thus bike and HGV trips in the Trics data were seemingly over-estimated, compared to the values observable in the official counts for these modes, whereas LGV trips looked under-estimated.

To end with the shortcomings related to matrices estimation, the basic method used to calculate pre-peak matrices from peak matrices can be emphasized: no projections from the initial RSI distribution (and the unitary matrix), using target margins based on appropriate counts, have been carried out for these estimations. As a result, the ten pre-peak matrices are expected to be reliable at not more than 85% compared to the real situation, despite they have all been calibrated with 100% of acceptable GEH.

Concerning calibration and validation methods, their primary inconveniences are they also depend on subjective reasoning. Many options allow to transfer over-estimated flows from one zone to another in the VISUM matrices calibration process, and then improve the accepted GEH proportion. But each particular option alters the originally estimated matrices differently and ultimately makes the final matrices' distribution fairly uncertain. As the calibration was merely based on road segments included in the 2008 junction counts, flows could be shifted with a comfortable degree of freedom on the other portions of the network, without affecting the GEH: this could entail significant changes in the original matrices' values, and maybe distort reality.

To finish, the fact some network elements of the VISSIM model have had to be adjusted to facilitate the calibration or validation procedure (green times enhancements compared to the original timings database for certain signal heads, desired and reduced speed increases, *etc.*) evidences slight alterations of the final reproduction that are not necessarily faithful to reality. The commitment aimed at calibrating and validating the model may then have led to disregard the real traffic conditions in a few cases.

*Synthesis:*

- VISUM, a powerful transport planning software allowing to assess elaborate transport demand and observe flows spreading across a network.
- A trips demand estimation inspired from the widespread four-step model, operated through miscellaneous indispensable data and a rigorous calculation methodology.
- VISUM calibration and VISSIM calibration/validation processes which led, after necessary automatic and manual adjustments, to 100% of accepted GEH in both simulators and a fully validated VISSIM model.
- Indisputable limitations regarding the demand estimation procedures and the calibration/ validation stages, mainly due to the database's imperfection and the consequent quantity of assumptions which have been carried out.

## Conclusion

This memoir reviewed the whole model building process that was necessary to operate within the scope of such a strategic project. Supposed to provide with a tool able to proceed to advanced traffic testing and elaborate analyses, the successive procedures depicted in the document proved to have led to the expected reliable model.

This model will be valid to back Merseyside authorities through the ensuing policies they will have to implement in the transport field. It will help them to cope with the current and forthcoming Local Transport Plans and achieve the objectives related to the entire transport network's reliability.

Like all other road infrastructure replications amid the eleven the global project encompasses, the Birkenhead corridor modelling concerned a particular territory, with its specific geographical attributes, its specific economic and socio-demographic trends. In the case of Birkenhead and its borough, Wirral, the project appears extremely relevant to allow the city and its urban area to face the surging road traffic volumes, the increasing car ownership and use, the slumping public transport plebiscite, and the resulting congestion of its road transport infrastructures. If not fought, the current Birkenhead and Wirral situations are likely to lead the territory to an erosion of its economic competitiveness and quality of life, what local authorities obviously search to avoid in a globally encouraging economic and demographic context for Wirral. In particular, buses operations could benefit substantially from the current LTP's main target which consists in lowering global journey times: road public transport services bear presently insufficient travel time performances, accompanying private vehicles in the frequently jammed traffic. Bringing buses journey times down may stand for a primary option in an attempt to incite people to leave cars, improve the public transport's attractiveness and finally make its patronage grow again.

Decision-makers will be henceforth be provided with pertinent traffic analyses regarding one Wirral's most congested infrastructure: the Birkenhead's A552 corridor. Over a selected portion of the corridor, all inescapable traffic elements have been reproduced virtually to finally obtain a simulation amongst the most realistic: faithful replication of the road designs and characteristics, traffic composition, speed distributions, priority rules, traffic signals coding, public transport lines, traffic production and attraction points. And above all, a meticulous estimation of the transport demand crossing the network has been achieved, following the most common calculation methods and models. As a result, virtual simulations of the A552's traffic conditions can be proceeded trustfully within the framework of a subsequent testing programme, which will start once all eleven routes will be utterly modelled.

Nevertheless, as repeatedly when it concerns virtual representations of real situations, the calibrated and validated model contains its own limitations anyhow: a range of simplifications, assumptions, incomplete or imperfect sources of information prevented from carrying out a perfect replication of reality. All further analyses that will be operated through the model will then need to mind these inescapable inconveniences and use the tool with the necessary distance required.

## List of abbreviations

ATC: Automatic Traffic Counts

Dft: Department for Transport

GEH: Geoffrey E. Havers's indicator

HGV: Heavy Goods Vehicles

ITB: Integrated Transport Division (Mott MacDonald)

LGV: Light Goods Vehicles

LTP: Local Transport Plan

MIS: Merseyside Information Service (Mott MacDonald)

OD: Origins/Destinations

ONS: Office of National Statistics

VA: Vehicle Actuated

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  http://www.wirral.gov.uk,

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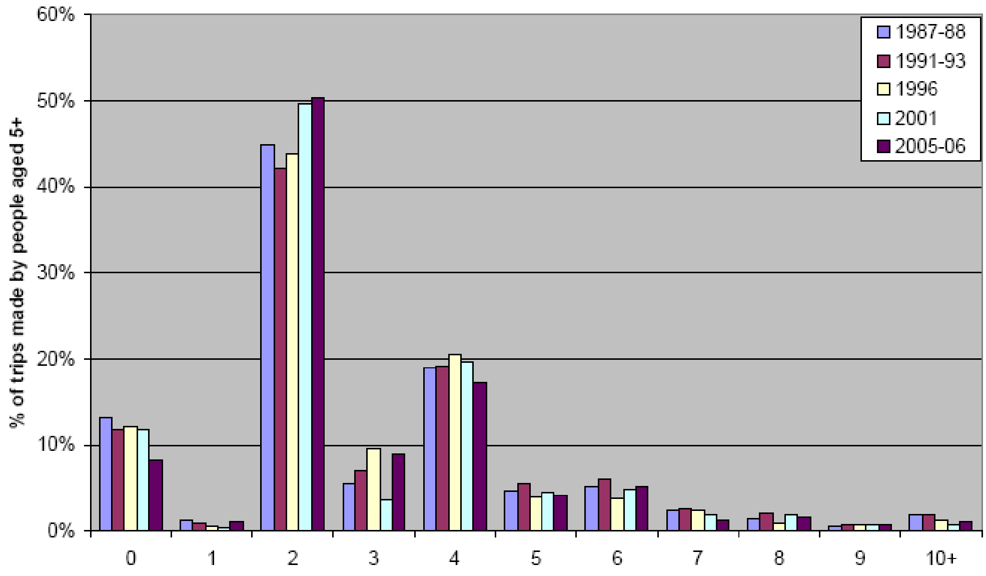
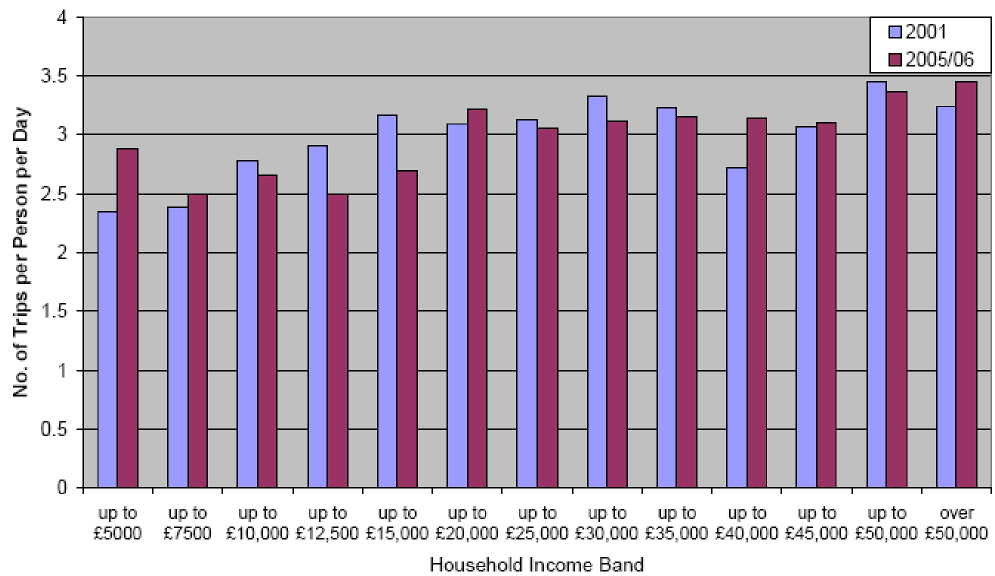
## Appendix 1: Number of trips made in Wirral



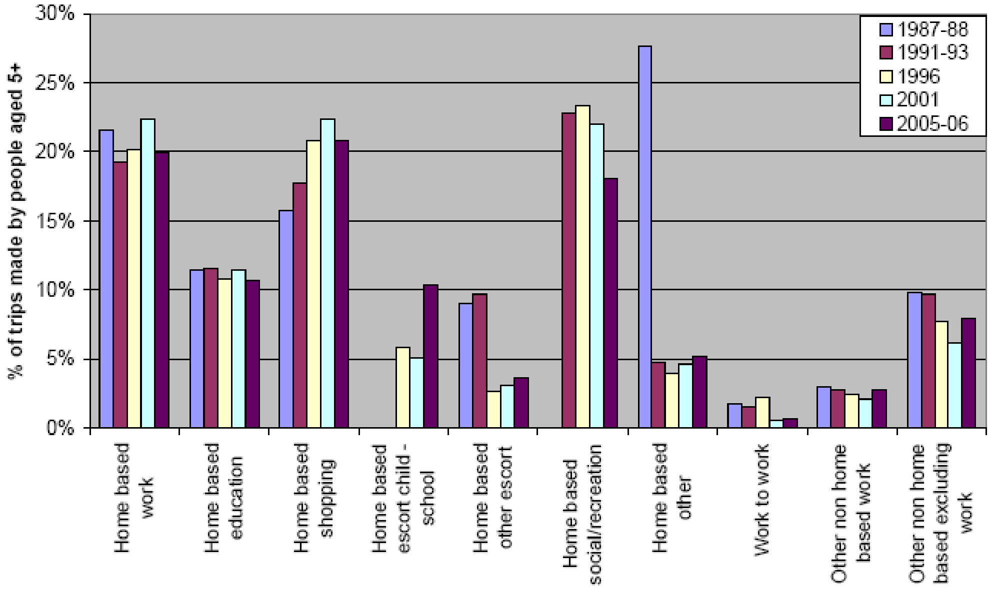

*Source: Wirral Countywide Travel Survey 2005/2006*

## Appendix 2: Number of trips per person by household annual income 2001, 2005/2006 (Merseyside)



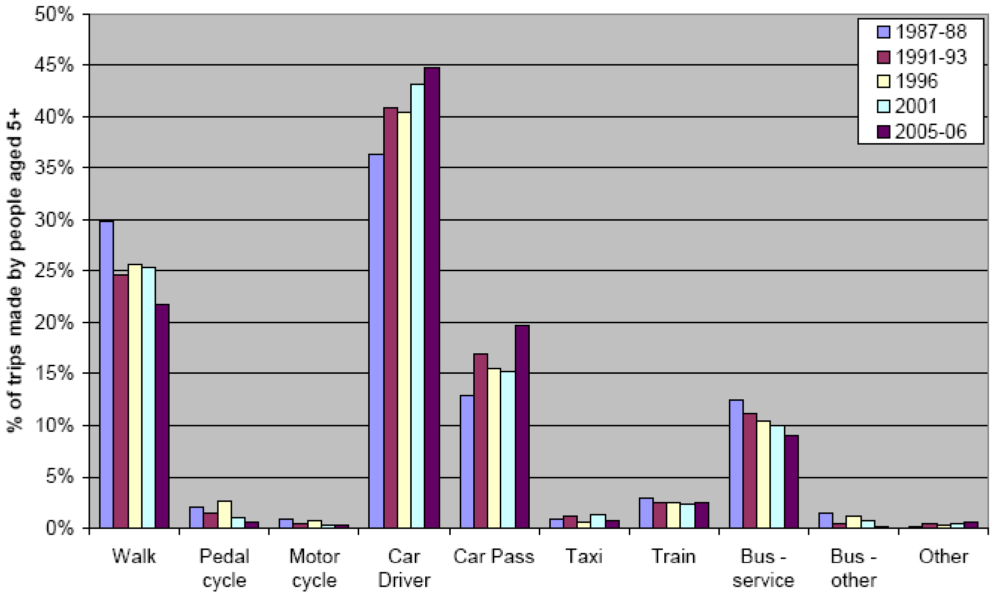

*Source: Wirral Countywide Travel Survey 2005/2006*

**Appendix 3: Overall trip purpose in Wirral**



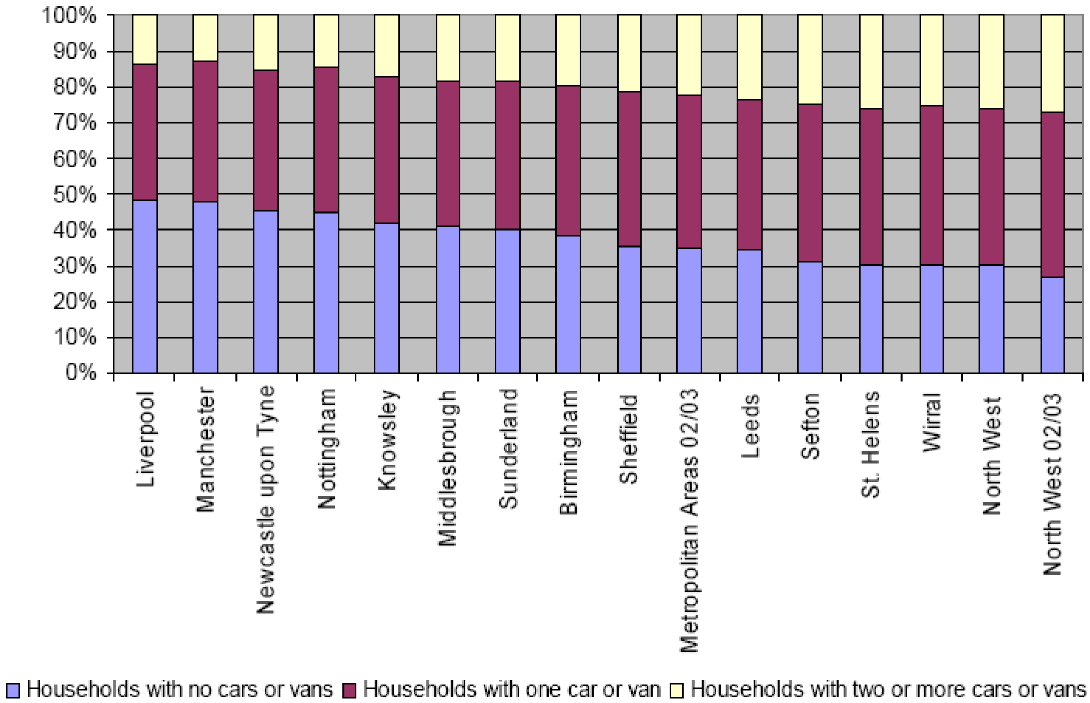

*Source: Wirral Countywide Travel Survey 2005/2006*

**Appendix 4: Main mode of travel in Wirral**



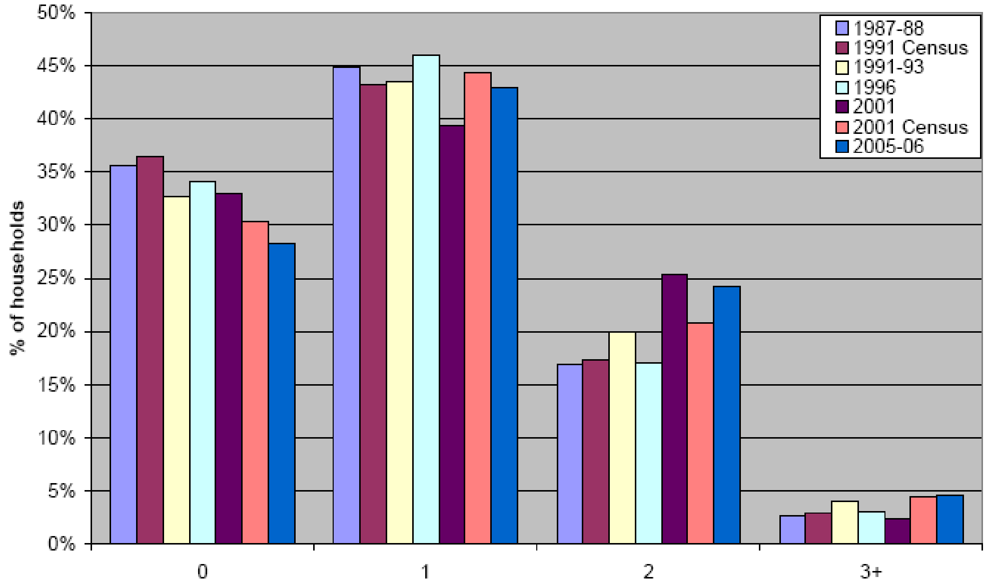

*Source: Wirral Countywide Travel Survey 2005/2006*

**Appendix 5: Car ownership in selected UK urban areas and Merseyside districts, 2001**



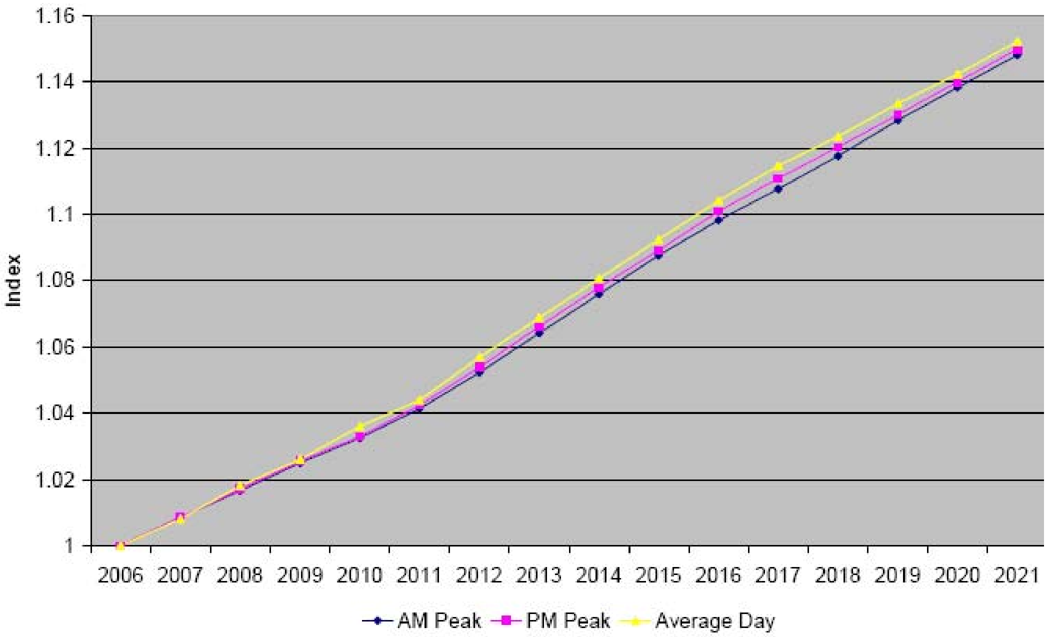

*Source: http://www.nationalstatistics.gov.uk*

**Appendix 6: Cars generally available in Merseyside**



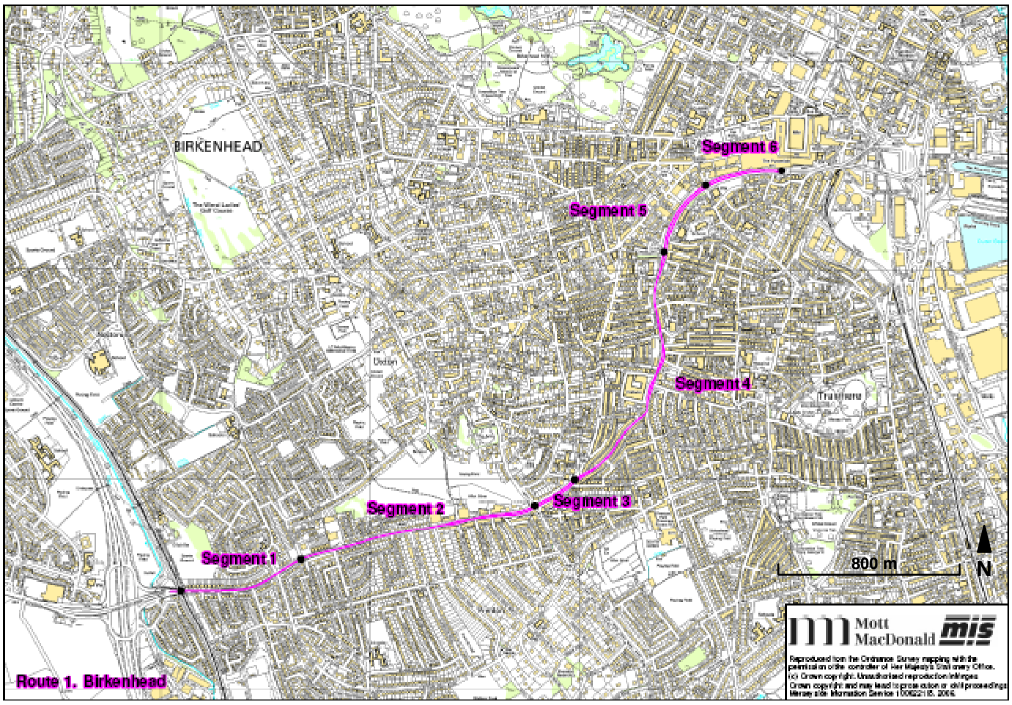

*Source: Wirral Countywide Travel Survey 2005/2006, Census1991, Census 2001*

**Appendix 7: Projected traffic growth in Wirral (2006 base, TEMPRO central factors)**




*Source: Wirral Countywide Travel Survey 2005/2006, Census1991, Census 2001*

**Appendix 8: Wirral person delay indicator**



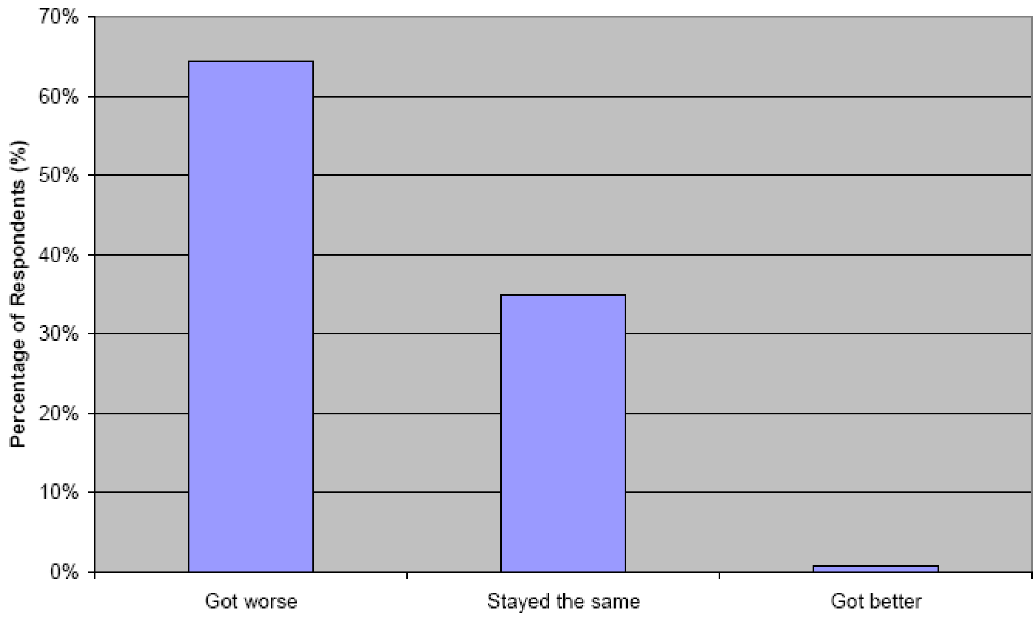

*Source: Mott MacDonald Mersyside Information Service (MIS)*

## Appendix 9: Perceptions of traffic congestion, 2004-2006 (%)

| | 2004 | 2004 | 2006 | 2006 |
|---|---|---|---|---|
| Perception of Congestion … | …in Nearest Town/ City Centre | …in Local Area | …in Local Area | …in Nearest Town/ City Centre |
| Not a problem | 14 | 23 | 32 | 17 |
| Problem most of the time | 59 | 59 | 53 | 59 |
| Problem at certain times of the day or week | 23 | 15 | 12 | 20 |
| Problem all of the time | 4 | 3 | 3 | 4 |

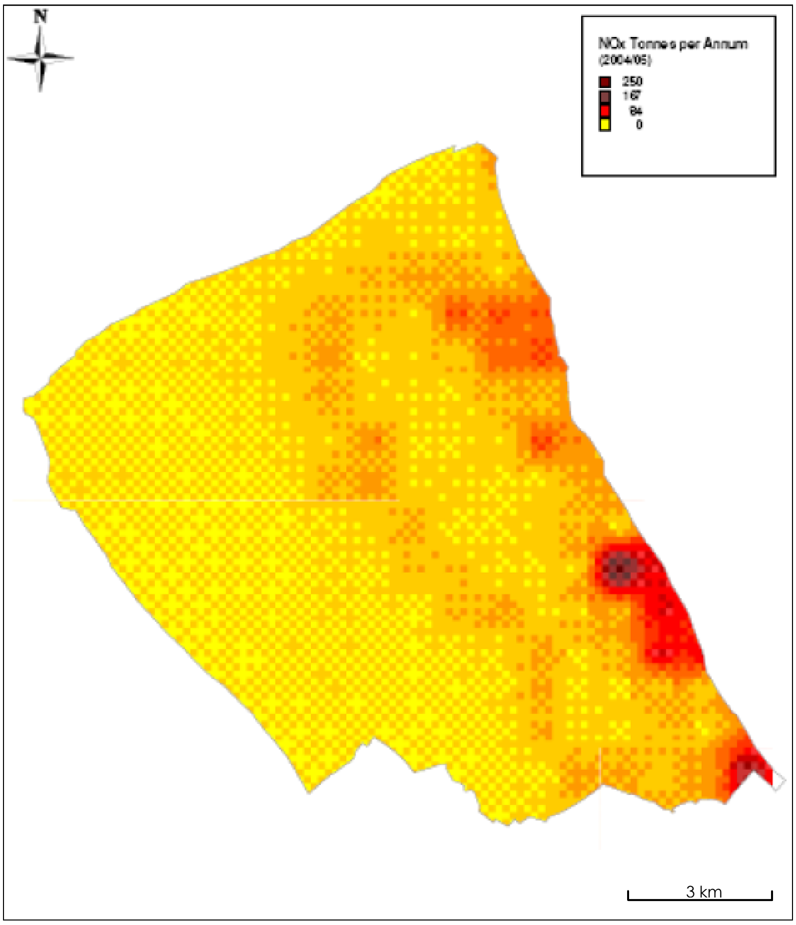
*Source: Wirral citizens panel (2006)*

## Appendix 10: Perception of change in traffic congestion in Wirral, 2005-2007



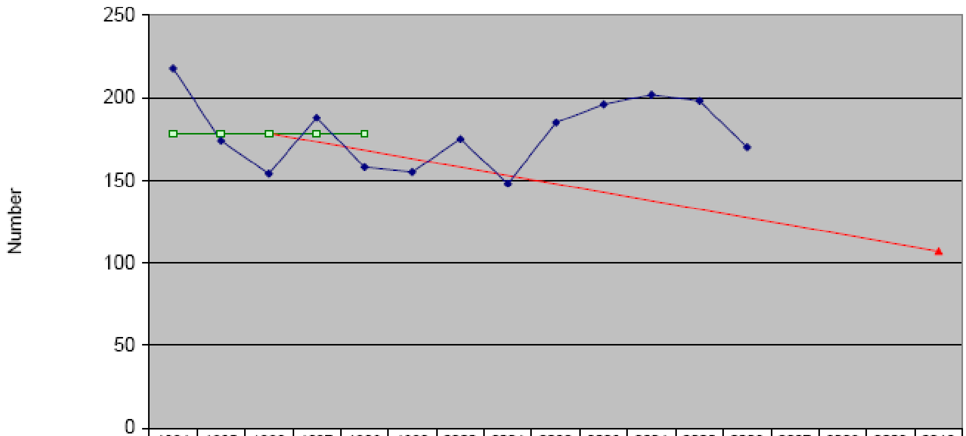

*Source: Wirral citizens panel (2007)*

**Appendix 11: Pollution Concentrates for Nitrogen Dioxide in Wirral (2004/05)**




*Source: Merseyside emissions inventory (2008)*

## Appendix 12: Wirral road casualties - Killed or seriously injured (all ages)

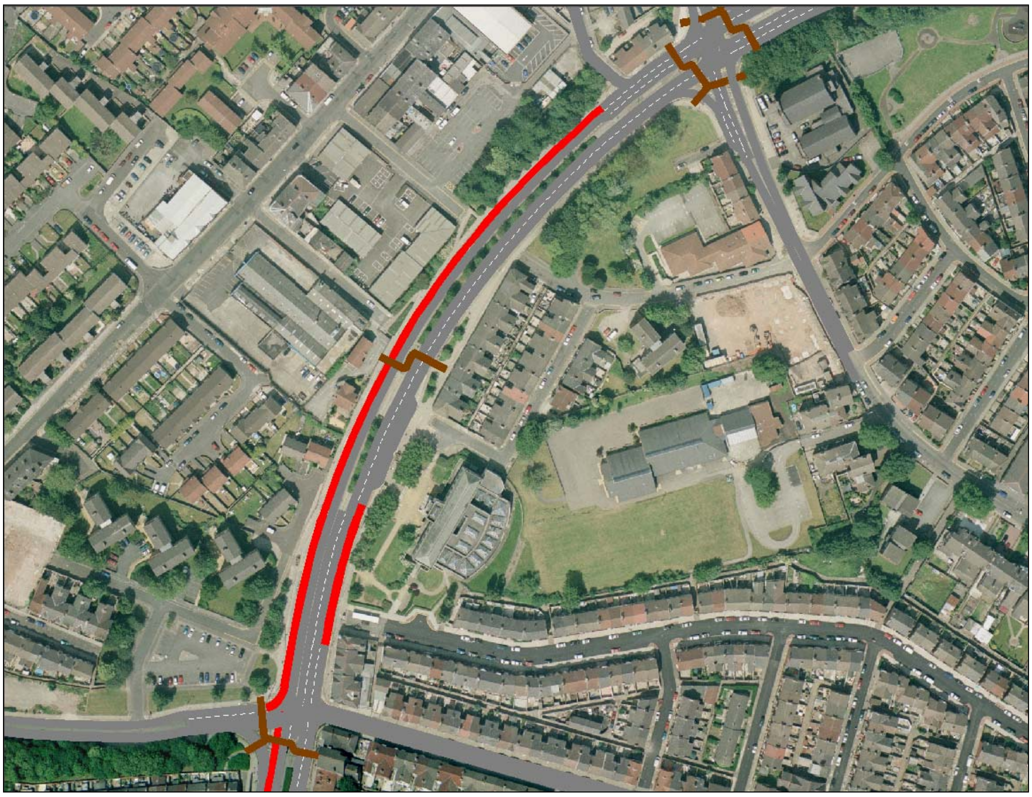



| | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| base | 178 | 178 | 178 | 178 | 178 | | | | | | | | | | | | |
| trajectory | | | 178 | 173 | 168 | 163 | 158 | 153 | 148 | 143 | 138 | 133 | 127 | 122 | 117 | 112 | 107 |
| 2010 target | | | | | | | | | | | | | | | | | 107 |
| KSI | 218 | 174 | 154 | 188 | 158 | 155 | 175 | 148 | 185 | 196 | 202 | 198 | 170 | | | | |

Year

*Source: Metropolitan Borough of Wirral (2007)*

## Appendix 13: Division of the corridor's road lanes between buses and private vehicles



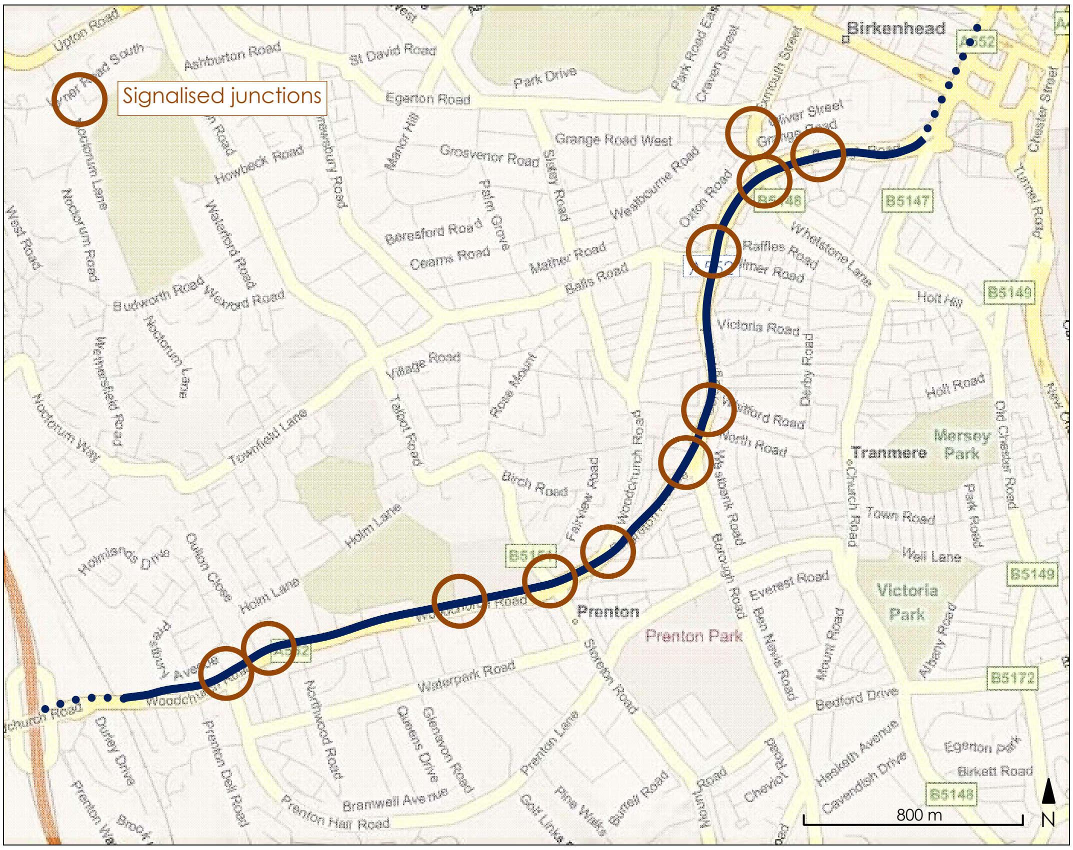
*Source: VISSIM illustration*

Bus lanes are highlighted in red in this illustration.

## Appendix 14: Yellow boxes over UK intersections

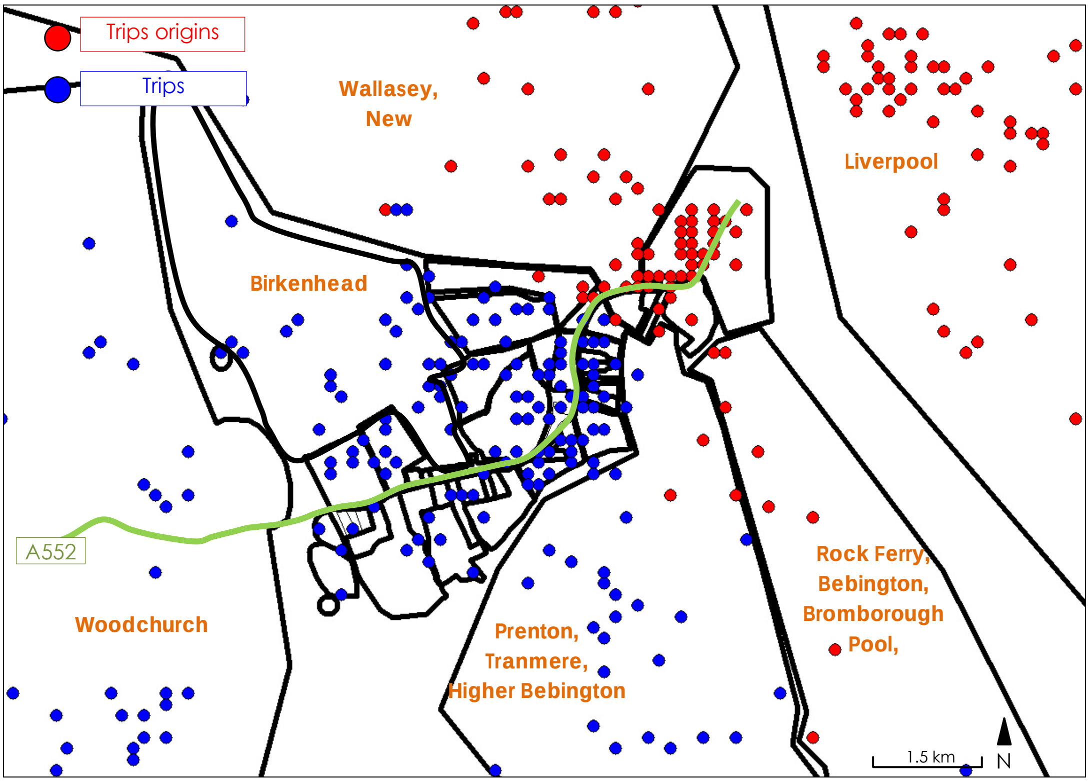
*Source: Google Earth illustration*

## Appendix 15: Signalised junctions across the Birkenhead corridor




*Source: http://maps.live.com*

## Appendix 16: Gathering of PM in bound trips' origins and destinations in the MapInfo zonal division




*Source: Raw RSI data (2003), MapInfo illustration*

## Appendix 17: Final GEH obtained after the AM peak matrices calibration in VISUM

| VISUM link n° | From VISUM node n° | To VISUM node n° | GEH Cars | GEH HGVs | GEH LGVs | GEH Motorcycles | GEH Cycles |
|---|---|---|---|---|---|---|---|
| 8 | 8 | 9 | 0,46 | 0,00 | 0,78 | 1,41 | 0,00 |
| 8 | 9 | 8 | 0,00 | 1,01 | 0,74 | 1,00 | 0,00 |
| 10 | 9 | 10 | 1,04 | 0,00 | 0,42 | 0,00 | 0,00 |
| 10 | 10 | 9 | 0,00 | 0,00 | 0,53 | 0,00 | 0,00 |
| 11 | 9 | 11 | 0,00 | 0,47 | 0,54 | 0,00 | 0,00 |
| 11 | 11 | 9 | 0,08 | 0,29 | 0,68 | 0,00 | 0,00 |
| 12 | 9 | 12 | 0,80 | 0,18 | 0,91 | 0,53 | 0,00 |
| 12 | 12 | 9 | 1,81 | 0,94 | 1,13 | 0,53 | 0,00 |
| 29 | 27 | 29 | 0,83 | 0,74 | 1,13 | 1,18 | 0,00 |
| 29 | 29 | 27 | 0,81 | 0,79 | 1,07 | 0,53 | 0,00 |
| 31 | 29 | 92 | 0,16 | 0,76 | 0,00 | 0,00 | 0,00 |
| 31 | 92 | 29 | 0,10 | 0,00 | 0,00 | 0,00 | 0,00 |
| 43 | 41 | 43 | 0,64 | 0,55 | 0,54 | 1,33 | 0,63 |
| 43 | 43 | 41 | 0,92 | 0,00 | 0,11 | 0,53 | 0,00 |
| 44 | 70 | 102 | 0,38 | 0,21 | 0,00 | 1,15 | 0,00 |
| 44 | 102 | 70 | 0,10 | 0,65 | 0,43 | 0,79 | 0,00 |
| 45 | 43 | 46 | 0,20 | 0,37 | 0,28 | 0,00 | 0,63 |
| 45 | 46 | 43 | 0,10 | 0,00 | 0,30 | 0,00 | 0,00 |
| 54 | 52 | 53 | 1,75 | 0,00 | 0,65 | 0,82 | 0,00 |
| 54 | 53 | 52 | 2,20 | 0,00 | 0,55 | 0,63 | 0,00 |
| 55 | 53 | 54 | 0,00 | 1,41 | 2,00 | 0,00 | 0,00 |
| 55 | 54 | 53 | 0,17 | 0,00 | 0,00 | 0,00 | 0,00 |
| 56 | 53 | 55 | 1,57 | 0,00 | 0,00 | 0,00 | 0,00 |
| 56 | 55 | 53 | 0,19 | 0,00 | 0,00 | 0,00 | 0,00 |
| 57 | 45 | 101 | 0,33 | 0,00 | 0,63 | 0,00 | 0,00 |
| 57 | 101 | 45 | 1,82 | 0,34 | 0,14 | 1,71 | 0,00 |
| 73 | 70 | 71 | 0,29 | 0,60 | 0,43 | 0,00 | 0,00 |
| 73 | 71 | 70 | 0,43 | 0,43 | 0,28 | 0,00 | 0,00 |
| 74 | 70 | 72 | 0,00 | 0,00 | 0,00 | 0,82 | 0,00 |
| 74 | 72 | 70 | 0,00 | 0,00 | 0,35 | 0,00 | 0,00 |
| 75 | 70 | 75 | 0,14 | 1,38 | 2,09 | 1,03 | 0,00 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 79 | 74 | 85 | 0,24 | 0,00 | 0,34 | 0,00 | 0,00 |
| 79 | 85 | 74 | 0,85 | 0,23 | 0,29 | 1,15 | 0,00 |
| 82 | 76 | 78 | 1,31 | 0,00 | 1,25 | 0,00 | 1,41 |
| 82 | 78 | 76 | 0,00 | 0,00 | 0,66 | 0,00 | 0,00 |
| 84 | 77 | 78 | 0,00 | 0,00 | 0,89 | 0,00 | 0,00 |
| 84 | 78 | 77 | 0,00 | 0,00 | 1,23 | 0,00 | 0,00 |
| 85 | 78 | 80 | 0,55 | 0,00 | 1,30 | 0,00 | 0,00 |
| 85 | 80 | 78 | 3,08 | 0,25 | 0,36 | 0,00 | 0,00 |
| 86 | 78 | 83 | 0,44 | 0,27 | 1,48 | 0,00 | 0,00 |
| 86 | 83 | 78 | 0,47 | 0,31 | 1,23 | 0,00 | 0,53 |
| 89 | 80 | 82 | 0,78 | 0,00 | 1,19 | 0,00 | 0,00 |
| 89 | 82 | 80 | 3,09 | 0,25 | 0,36 | 0,00 | 0,63 |
| 91 | 85 | 86 | 0,28 | 0,43 | 0,00 | 0,00 | 0,00 |
| 91 | 86 | 85 | 0,76 | 0,00 | 0,71 | 0,00 | 0,00 |
| 100 | 53 | 94 | 0,44 | 0,00 | 0,11 | 1,07 | 0,00 |
| 100 | 94 | 53 | 0,28 | 0,21 | 0,00 | 1,15 | 0,00 |
| 101 | 93 | 85 | 2,76 | 0,68 | 0,00 | 1,15 | 0,00 |
| 102 | 85 | 96 | 1,10 | 0,24 | 0,90 | 0,00 | 0,00 |
| 103 | 74 | 70 | 0,48 | 1,33 | 1,90 | 2,00 | 0,00 |
| 105 | 29 | 99 | 0,11 | 0,00 | 0,64 | 1,18 | 0,00 |
| 105 | 99 | 29 | 2,14 | 0,26 | 0,50 | 0,53 | 0,00 |

*Source: Excel calculation*

## Appendix 18: Final GEH obtained after the PM peak matrices calibration in VISUM

| VISUM link n° | From VISUM node n° | To VISUM node n° | GEH Cars | GEH HGVs | GEH LGVs | GEH Motorcycles | GEH Cycles |
|---|---|---|---|---|---|---|---|
| 8 | 8 | 9 | 0,36 | 1,15 | 1,06 | 0,00 | 1,41 |
| 8 | 9 | 8 | 0,19 | 0,43 | 1,35 | 0,63 | 2,45 |
| 10 | 9 | 10 | 0,64 | 1,41 | 0,00 | 0,00 | 0,00 |
| 10 | 10 | 9 | 0,32 | 1,41 | 0,29 | 0,00 | 0,00 |
| 11 | 9 | 11 | 0,05 | 1,41 | 0,38 | 0,00 | 0,00 |
| 11 | 11 | 9 | 0,34 | 0,00 | 0,82 | 0,00 | 0,00 |
| 12 | 9 | 12 | 0,67 | 0,00 | 0,36 | 0,47 | 1,41 |
| 12 | 12 | 9 | 0,03 | 0,00 | 1,58 | 0,00 | 2,45 |
| 29 | 27 | 29 | 0,25 | 1,15 | 1,28 | 1,83 | 2,00 |
| 29 | 29 | 27 | 0,80 | 0,82 | 1,49 | 0,00 | 1,41 |
| 31 | 29 | 92 | 0,11 | 0,00 | 0,00 | 0,53 | 0,00 |
| 31 | 92 | 29 | 0,10 | 0,00 | 0,25 | 0,00 | 0,00 |
| 43 | 41 | 43 | 0,24 | 0,47 | 0,55 | 0,00 | 2,00 |
| 43 | 43 | 41 | 0,48 | 0,00 | 0,60 | 0,37 | 0,53 |
| 44 | 70 | 102 | 0,23 | 0,31 | 0,62 | 0,28 | 1,26 |
| 44 | 102 | 70 | 0,24 | 0,43 | 0,94 | 0,00 | 0,82 |
| 45 | 43 | 46 | 0,11 | 0,53 | 0,00 | 0,00 | 0,00 |
| 45 | 46 | 43 | 0,05 | 0,00 | 0,38 | 0,82 | 1,41 |
| 54 | 52 | 53 | 0,60 | 1,51 | 2,12 | 0,32 | 0,82 |
| 54 | 53 | 52 | 0,94 | 0,63 | 1,18 | 0,31 | 1,54 |
| 55 | 53 | 54 | 0,31 | 0,00 | 0,00 | 0,00 | 0,00 |
| 55 | 54 | 53 | 0,59 | 0,00 | 0,00 | 0,00 | 0,00 |
| 56 | 53 | 55 | 0,32 | 0,47 | 0,47 | 0,63 | 0,00 |
| 56 | 55 | 53 | 0,40 | 0,63 | 0,53 | 0,00 | 0,00 |
| 57 | 45 | 101 | 0,05 | 0,32 | 0,20 | 1,18 | 2,83 |
| 57 | 101 | 45 | 0,64 | 0,53 | 0,50 | 0,34 | 1,41 |
| 73 | 70 | 71 | 0,14 | 1,18 | 0,39 | 0,71 | 0,00 |
| 73 | 71 | 70 | 0,33 | 0,53 | 1,04 | 0,82 | 0,82 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 74 | 70 | 72 | 0,37 | 0,00 | 0,23 | 0,00 | 0,00 |
| 74 | 72 | 70 | 0,43 | 0,63 | 1,15 | 0,00 | 0,00 |
| 75 | 70 | 75 | 1,20 | 0,82 | 2,75 | 1,41 | 0,00 |
| 79 | 74 | 85 | 0,29 | 1,60 | 0,89 | 1,00 | 1,41 |
| 79 | 85 | 74 | 0,14 | 0,82 | 1,00 | 0,76 | 2,00 |
| 82 | 76 | 78 | 1,31 | 0,82 | 0,66 | 0,82 | 0,82 |
| 82 | 78 | 76 | 0,18 | 2,00 | 0,00 | 1,90 | 2,67 |
| 84 | 77 | 78 | 0,00 | 0,00 | 2,00 | 0,00 | 0,00 |
| 84 | 78 | 77 | 0,41 | 0,00 | 0,20 | 0,63 | 0,00 |
| 85 | 78 | 80 | 0,17 | 0,43 | 3,45 | 0,00 | 0,53 |
| 85 | 80 | 78 | 0,63 | 0,63 | 2,16 | 0,76 | 0,00 |
| 86 | 78 | 83 | 1,28 | 0,00 | 1,10 | 0,39 | 0,39 |
| 86 | 83 | 78 | 0,69 | 0,00 | 1,54 | 0,39 | 0,63 |
| 89 | 80 | 82 | 0,25 | 0,43 | 2,95 | 0,47 | 0,53 |
| 89 | 82 | 80 | 0,71 | 0,63 | 2,16 | 0,76 | 0,00 |
| 91 | 85 | 86 | 1,07 | 0,00 | 1,47 | 0,00 | 0,00 |
| 91 | 86 | 85 | 2,12 | 0,00 | 0,39 | 0,00 | 0,00 |
| 100 | 53 | 94 | 0,08 | 0,43 | 0,41 | 0,34 | 0,82 |
| 100 | 94 | 53 | 0,43 | 0,31 | 0,52 | 0,58 | 1,54 |
| 101 | 93 | 85 | 0,68 | 0,82 | 2,38 | 1,03 | 2,00 |
| 102 | 85 | 96 | 1,14 | 1,60 | 2,07 | 1,41 | 1,41 |
| 103 | 74 | 70 | 0,53 | 0,82 | 3,17 | 0,92 | 0,32 |
| 105 | 29 | 99 | 0,41 | 1,15 | 0,00 | 1,03 | 2,00 |
| 105 | 99 | 29 | 0,04 | 0,82 | 0,20 | 0,39 | 1,41 |

*Source: Excel calculation*

## Appendix 19: Final GEH obtained after the AM peak matrices calibration in VISSIM

| VISSM link ID | GEH Cars | GEH HGVs | GEH LGVs | GEH Motorcycles | GEH Cycles |
|---|---|---|---|---|---|
| 1511 | 0,62 | 0,04 | 0,86 | 1,24 | 0,00 |
| 1521 | 1,30 | 1,22 | 1,08 | 1,23 | 0,00 |
| 1531 | 1,08 | 0,00 | 0,42 | 0,00 | 0,00 |
| 1541 | 0,01 | 0,00 | 0,53 | 0,00 | 0,00 |
| 1571 | 0,66 | 0,47 | 0,35 | 0,00 | 0,00 |
| 1581 | 1,87 | 0,12 | 0,03 | 0,00 | 0,00 |
| 1551 | 1,80 | 0,07 | 1,05 | 0,42 | 0,00 |
| 1561 | 2,09 | 1,20 | 1,13 | 0,77 | 0,00 |
| 1311 | 0,03 | 0,74 | 1,13 | 1,18 | 0,14 |
| 1361 | 1,10 | 0,53 | 1,03 | 0,65 | 0,00 |
| 1321 | 0,30 | 0,89 | 0,06 | 0,00 | 0,00 |
| 1331 | 0,10 | 0,00 | 0,00 | 0,00 | 0,00 |
| 1051 | 0,19 | 0,71 | 0,52 | 1,45 | 0,50 |
| 1041 | 1,13 | 0,33 | 0,04 | 0,53 | 0,11 |
| 571 | 0,67 | 0,30 | 0,00 | 1,15 | 0,00 |
| 581 | 1,17 | 0,56 | 0,68 | 0,79 | 0,20 |
| 1011 | 0,33 | 0,37 | 0,28 | 0,00 | 0,50 |
| 1061 | 0,20 | 0,00 | 0,24 | 0,00 | 0,00 |
| 881 | 2,20 | 0,00 | 0,67 | 0,92 | 0,00 |
| 871 | 2,68 | 0,13 | 0,70 | 0,63 | 0,00 |
| 811 | 0,27 | 1,41 | 2,00 | 0,00 | 0,00 |
| 821 | 0,14 | 0,00 | 0,00 | 0,00 | 0,00 |
| 851 | 1,81 | 0,30 | 0,05 | 0,00 | 0,00 |
| 861 | 0,19 | 0,00 | 0,00 | 0,00 | 0,00 |
| 1031 | 0,09 | 0,37 | 0,53 | 0,00 | 0,19 |
| 1021 | 1,61 | 0,54 | 0,11 | 1,83 | 0,00 |
| 511 | 0,46 | 0,54 | 0,57 | 0,24 | 0,00 |
| 521 | 0,65 | 0,43 | 0,36 | 0,12 | 0,00 |

| | | | | | |
|---|---|---|---|---|---|
| 551 | 0,21 | 0,12 | 0,16 | 0,82 | 0,00 |
| 561 | 0,15 | 0,00 | 0,39 | 0,00 | 0,00 |
| 531 | 0,78 | 1,42 | 1,83 | 1,08 | 0,20 |
| 111 | 2,15 | 0,27 | 0,74 | 0,09 | 0,19 |
| 121 | 1,97 | 0,19 | 0,29 | 1,15 | 0,00 |
| 251 | 4,03 | 0,11 | 0,16 | 0,11 | 0,19 |
| 241 | 1,05 | 0,15 | 1,23 | 0,00 | 0,00 |
| 212 | 0,00 | 0,00 | 2,00 | 0,00 | 0,00 |
| 211 | 0,19 | 0,00 | 1,23 | 0,00 | 0,00 |
| 221 | 0,97 | 0,06 | 1,15 | 0,00 | 0,10 |
| 231 | 3,43 | 0,36 | 0,46 | 0,00 | 0,15 |
| 271 | 1,91 | 0,44 | 1,50 | 0,10 | 0,63 |
| 261 | 0,29 | 0,37 | 0,88 | 0,00 | 0,43 |
| 131 | 0,77 | 0,80 | 0,00 | 0,30 | 0,00 |
| 141 | 0,76 | 0,00 | 0,71 | 0,00 | 0,00 |
| 831 | 0,05 | 0,09 | 0,09 | 1,17 | 0,00 |
| 841 | 0,77 | 0,08 | 0,21 | 1,15 | 0,00 |
| 161 | 0,10 | 0,63 | 0,00 | 1,15 | 0,00 |
| 151 | 3,42 | 0,34 | 1,25 | 0,18 | 0,19 |
| 541 | 0,25 | 1,26 | 1,88 | 2,00 | 0,00 |
| 1341 | 0,90 | 0,08 | 0,70 | 1,18 | 0,14 |
| 1351 | 2,46 | 0,00 | 0,45 | 0,53 | 0,00 |

*Source: Excel calculation*

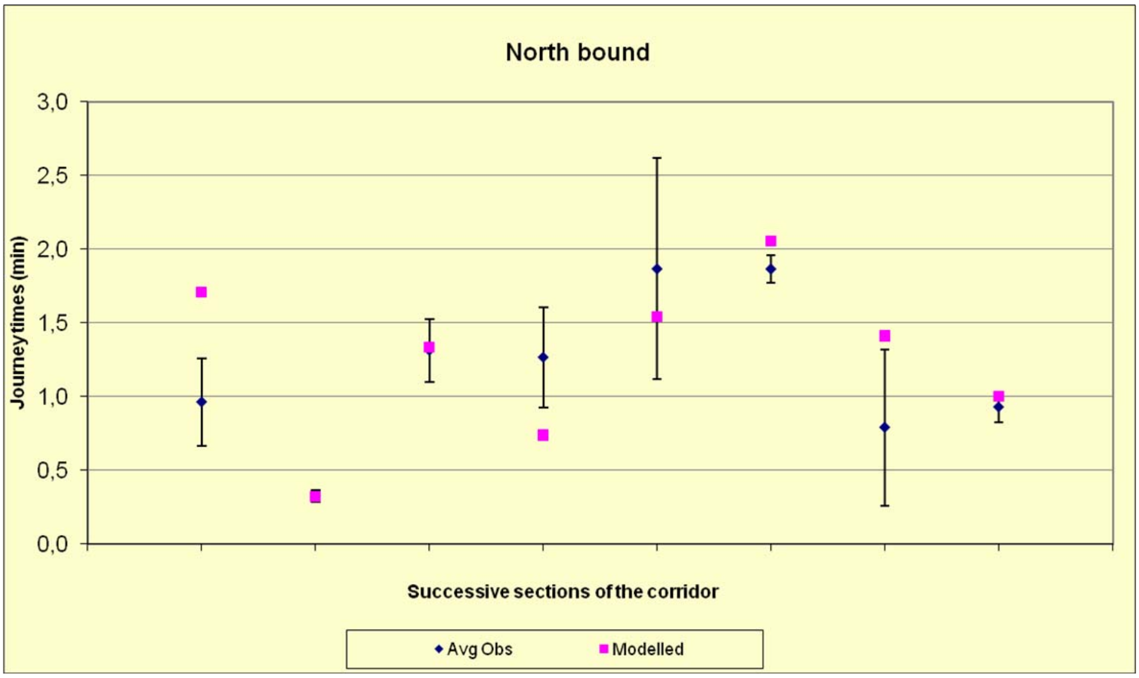
### Appendix 20: Final GEH obtained after the PM peak car matrix calibration in VISSIM

| VISSM link ID | GEH Cars | GEH HGVs | GEH LGVs | GEH Motorcycles | GEH Cycles |
|---|---|---|---|---|---|
| 1511 | 0,68 | 0,89 | 1,08 | 0,09 | 1,41 |
| 1521 | 1,38 | 0,70 | 1,59 | 0,50 | 2,45 |
| 1531 | 0,38 | 1,41 | 0,00 | 0,00 | 0,00 |
| 1541 | 0,26 | 1,41 | 0,29 | 0,00 | 0,00 |
| 1571 | 0,26 | 1,41 | 0,38 | 0,00 | 0,00 |
| 1581 | 1,60 | 0,00 | 0,58 | 0,00 | 0,00 |
| 1551 | 1,16 | 0,40 | 0,29 | 0,73 | 1,41 |
| 1561 | 0,68 | 0,28 | 1,61 | 0,11 | 2,45 |
| 1311 | 0,28 | 0,77 | 1,30 | 1,66 | 2,10 |
| 1361 | 0,50 | 1,00 | 1,42 | 0,09 | 1,41 |
| 1321 | 0,36 | 0,00 | 0,04 | 0,53 | 0,00 |
| 1331 | 0,08 | 0,00 | 0,25 | 0,00 | 0,00 |
| 1051 | 0,71 | 0,09 | 0,29 | 0,00 | 2,00 |
| 1041 | 0,91 | 0,13 | 0,85 | 0,22 | 0,33 |
| 571 | 1,11 | 0,13 | 0,57 | 0,34 | 1,33 |
| 581 | 0,05 | 0,00 | 0,91 | 0,07 | 0,63 |
| 1011 | 0,76 | 0,53 | 0,17 | 0,00 | 0,00 |
| 1061 | 0,12 | 0,00 | 0,42 | 0,82 | 1,41 |
| 881 | 0,88 | 1,26 | 2,06 | 0,19 | 0,82 |
| 871 | 1,94 | 0,77 | 0,96 | 0,25 | 1,68 |
| 811 | 0,19 | 0,00 | 0,08 | 0,00 | 0,00 |
| 821 | 0,63 | 0,00 | 0,09 | 0,00 | 0,00 |
| 851 | 0,65 | 0,68 | 0,42 | 0,50 | 0,00 |
| 861 | 0,46 | 0,63 | 0,53 | 0,00 | 0,00 |
| 1031 | 0,78 | 0,46 | 0,44 | 1,04 | 2,68 |
| 1021 | 0,33 | 0,21 | 0,35 | 0,34 | 1,41 |
| 511 | 0,88 | 1,09 | 0,49 | 0,63 | 0,00 |
| 521 | 0,40 | 0,53 | 1,07 | 0,82 | 0,82 |

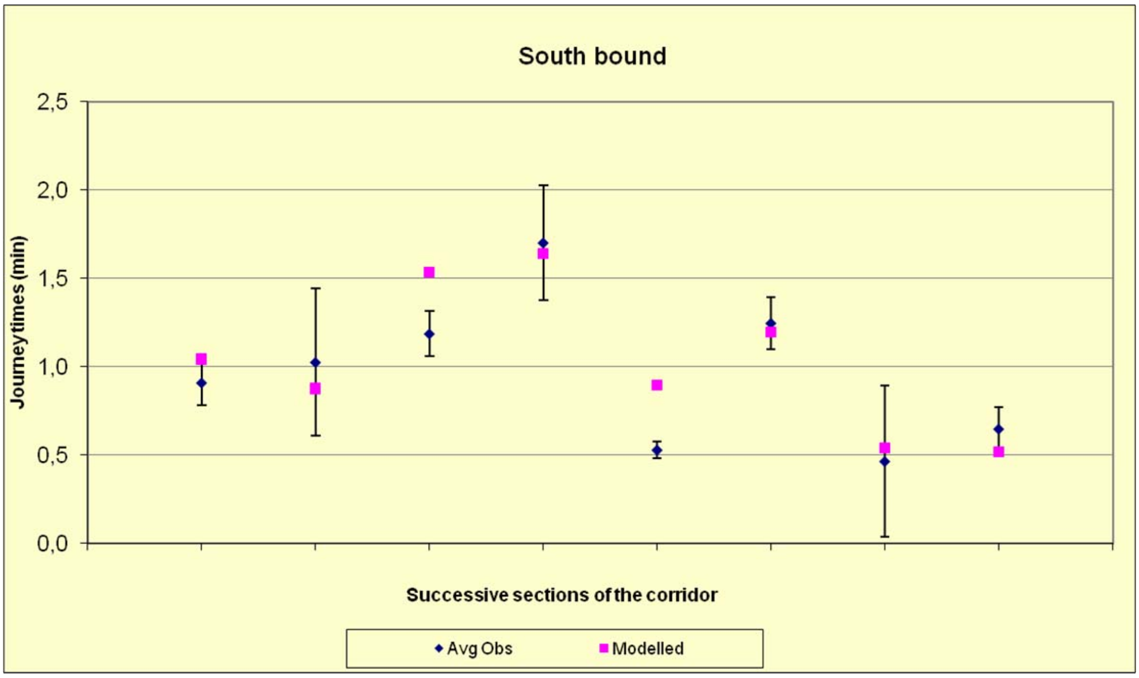
| | | | | | |
|---|---|---|---|---|---|
| 551 | 0,61 | 0,30 | 0,46 | 0,21 | 0,00 |
| 561 | 0,51 | 0,63 | 1,15 | 0,00 | 0,00 |
| 531 | 0,90 | 1,25 | 2,85 | 1,35 | 0,14 |
| 111 | 0,58 | 1,23 | 1,02 | 1,11 | 1,41 |
| 121 | 0,79 | 0,91 | 1,13 | 0,87 | 2,00 |
| 251 | 3,36 | 1,01 | 0,39 | 0,00 | 0,82 |
| 241 | 0,01 | 2,00 | 0,00 | 1,58 | 2,82 |
| 212 | 0,00 | 0,00 | 2,00 | 0,00 | 0,00 |
| 211 | 0,03 | 0,00 | 0,20 | 1,08 | 0,00 |
| 221 | 0,29 | 0,08 | 3,35 | 0,21 | 0,73 |
| 231 | 0,76 | 0,63 | 2,19 | 0,68 | 0,00 |
| 271 | 2,09 | 0,06 | 0,97 | 0,83 | 0,32 |
| 261 | 0,08 | 0,51 | 1,32 | 0,16 | 0,74 |
| 131 | 1,20 | 0,00 | 1,61 | 0,00 | 0,00 |
| 141 | 2,27 | 0,00 | 0,56 | 0,00 | 0,00 |
| 831 | 0,31 | 0,08 | 0,41 | 0,47 | 0,82 |
| 841 | 1,44 | 0,13 | 0,74 | 0,58 | 1,68 |
| 161 | 0,93 | 0,91 | 2,36 | 1,09 | 2,00 |
| 151 | 2,17 | 1,23 | 2,21 | 1,53 | 1,41 |
| 541 | 0,70 | 0,55 | 3,09 | 1,00 | 0,32 |
| 1341 | 0,87 | 0,77 | 0,00 | 0,95 | 2,19 |
| 1351 | 0,37 | 1,00 | 0,24 | 0,47 | 1,41 |

*Source: Excel calculation*

## Appendix 21: AM period average journey times and 95% confidence level boundary (north and south bounds)

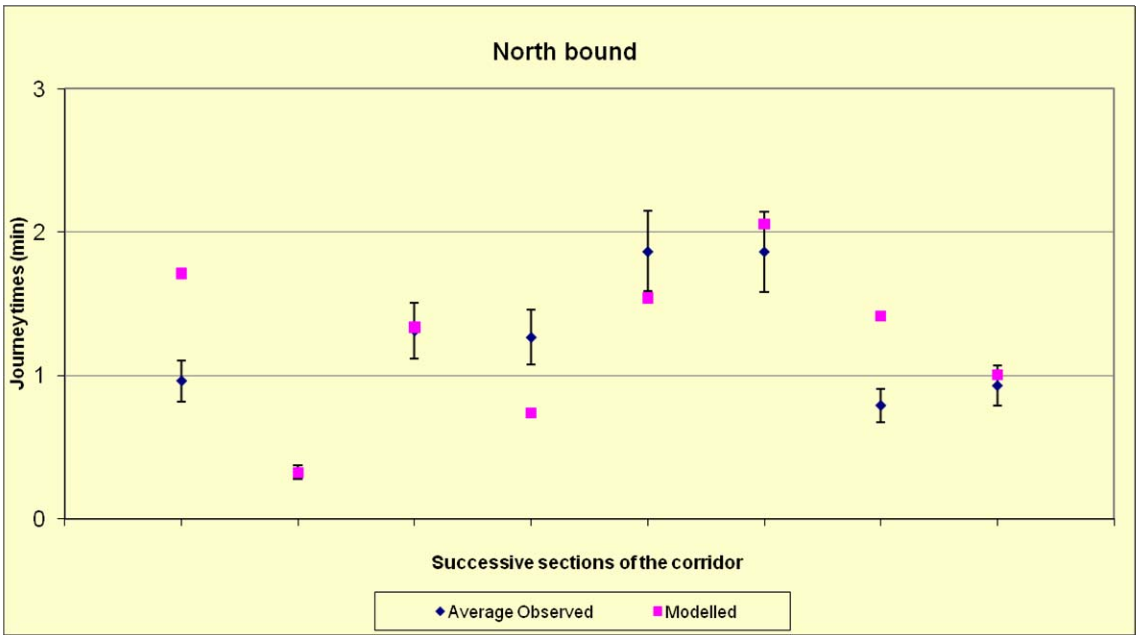



*Source: Excel calculation*

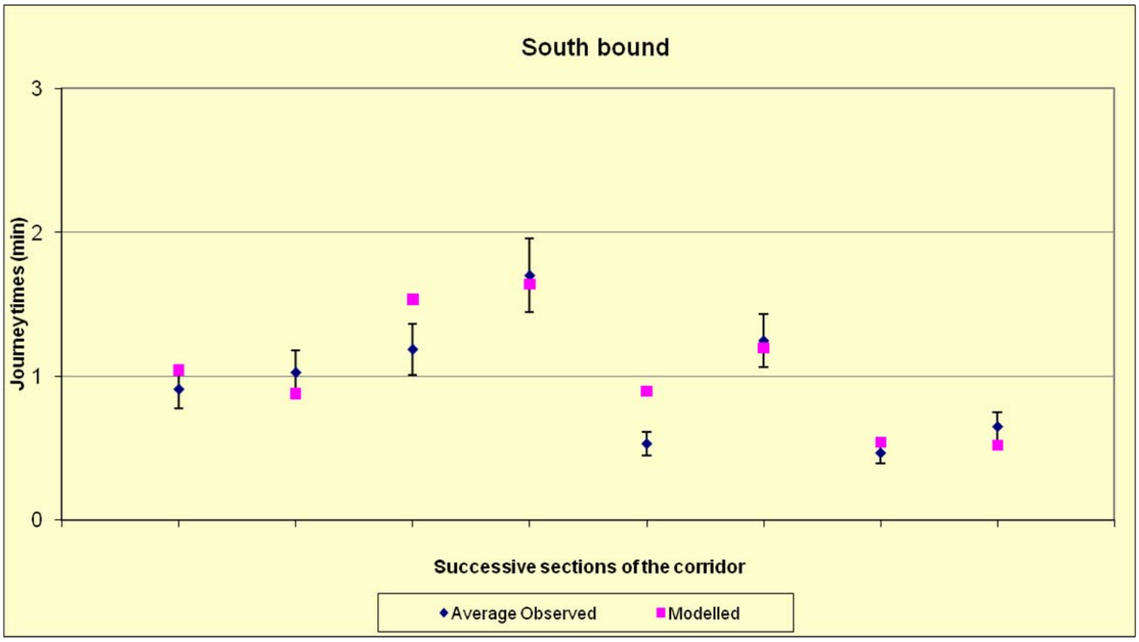



*Source: Excel calculation*

**Appendix 22: AM period average observed journey time and 15% boundary (north and south bounds)**

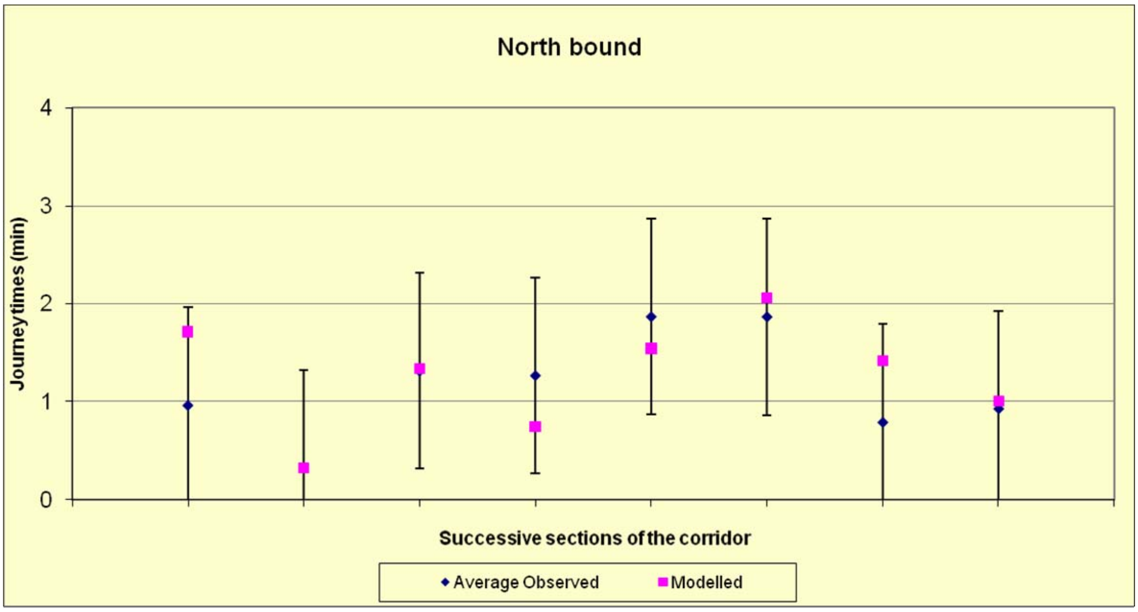



*Source: Excel calculation*

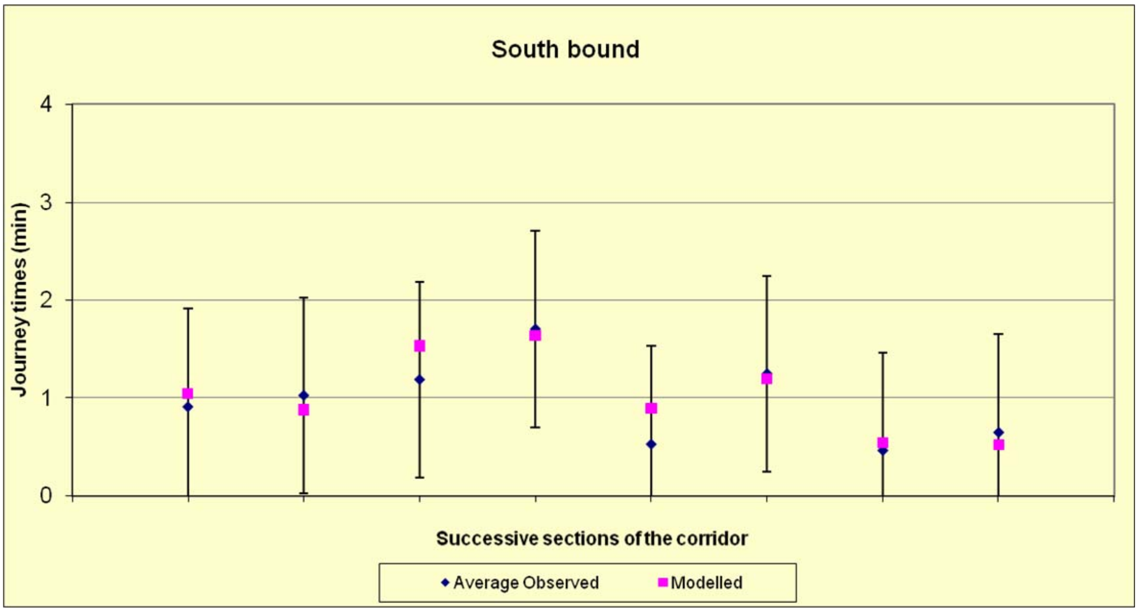



*Source: Excel calculation*

**Appendix 23: AM period average observed journey time and 1 minute boundary (north and south bounds)**

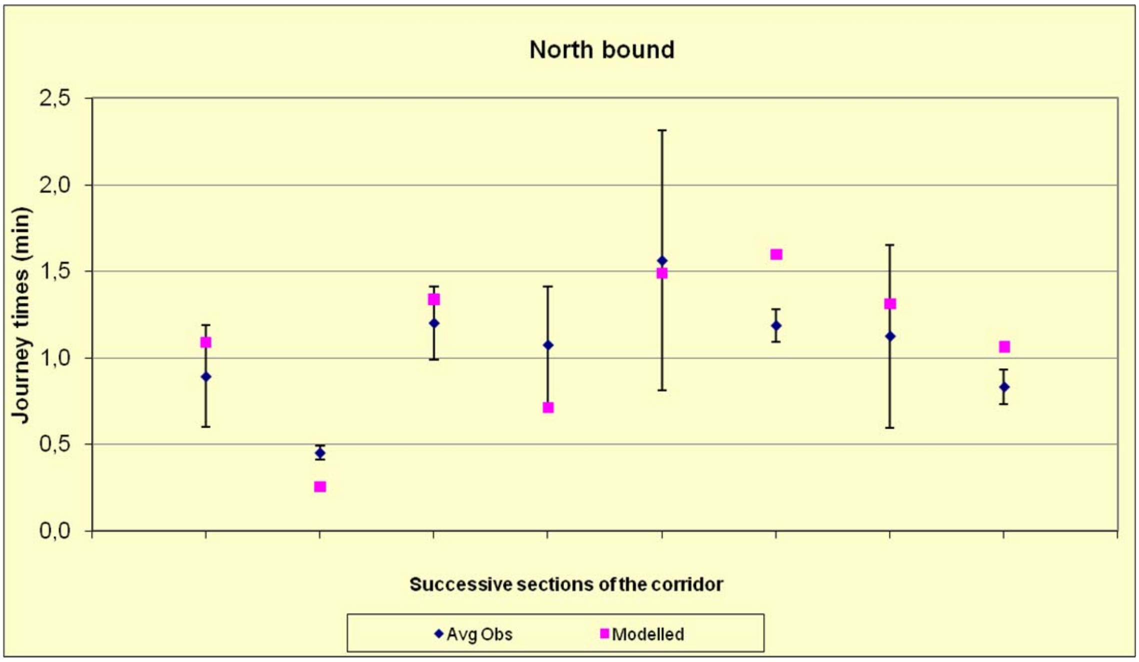



*Source: Excel calculation*

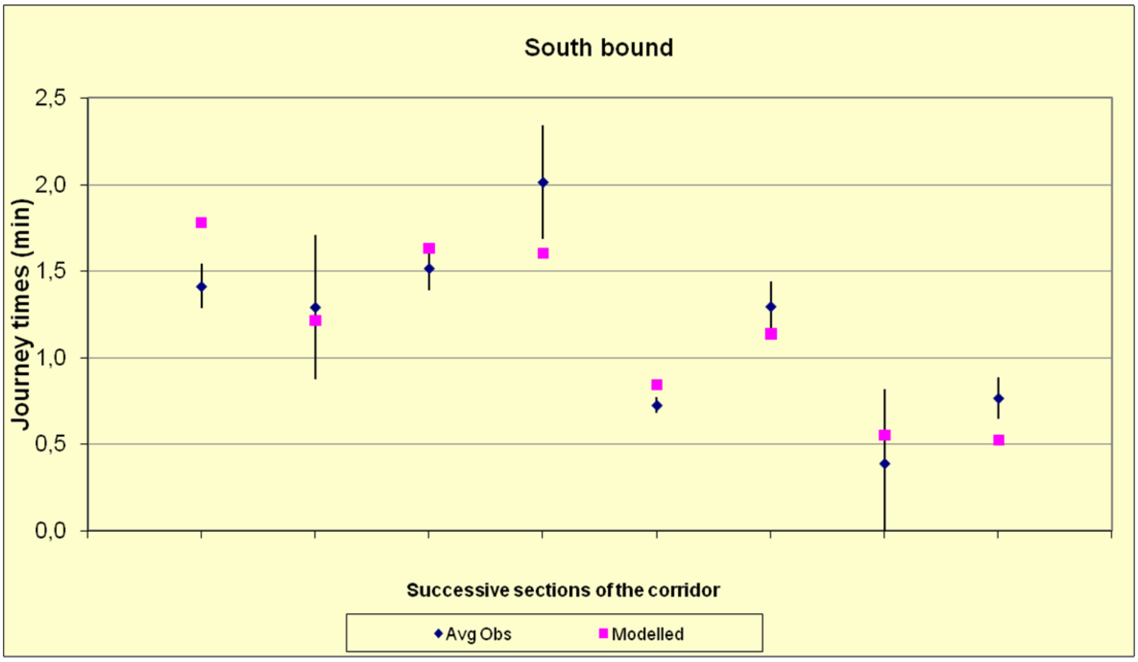



*Source: Excel calculation*

**Appendix 24: PM period average journey times and 95% confidence level boundary (north and south bounds)**

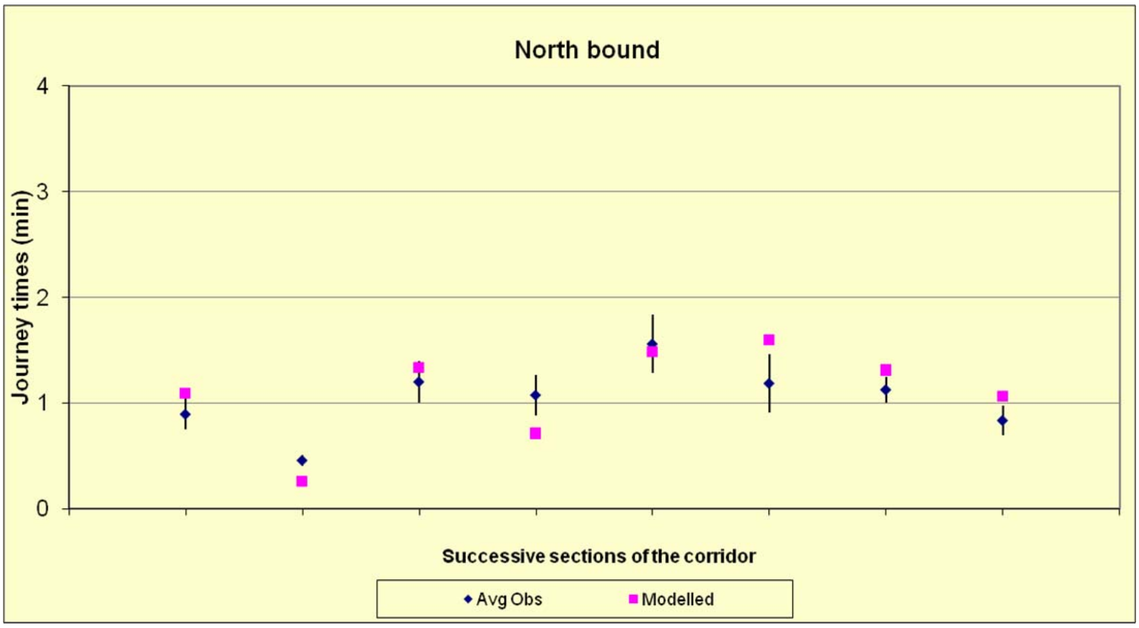



*Source: Excel calculation*

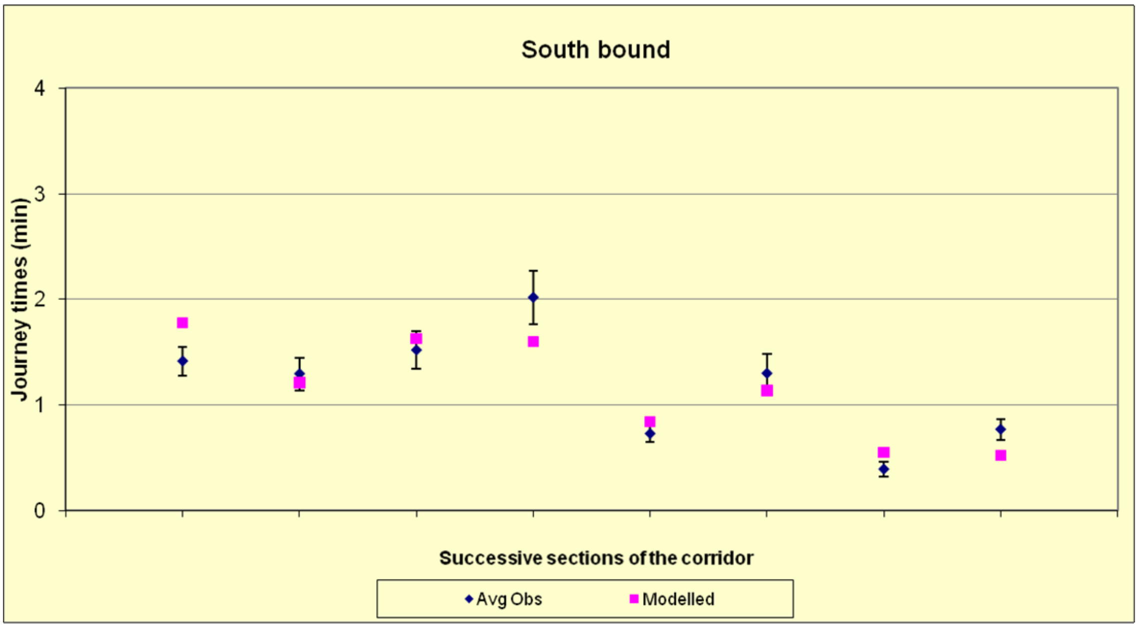



*Source: Excel calculation*

**Appendix 25: PM period average observed journey time and 15% boundary (north and south bounds)**

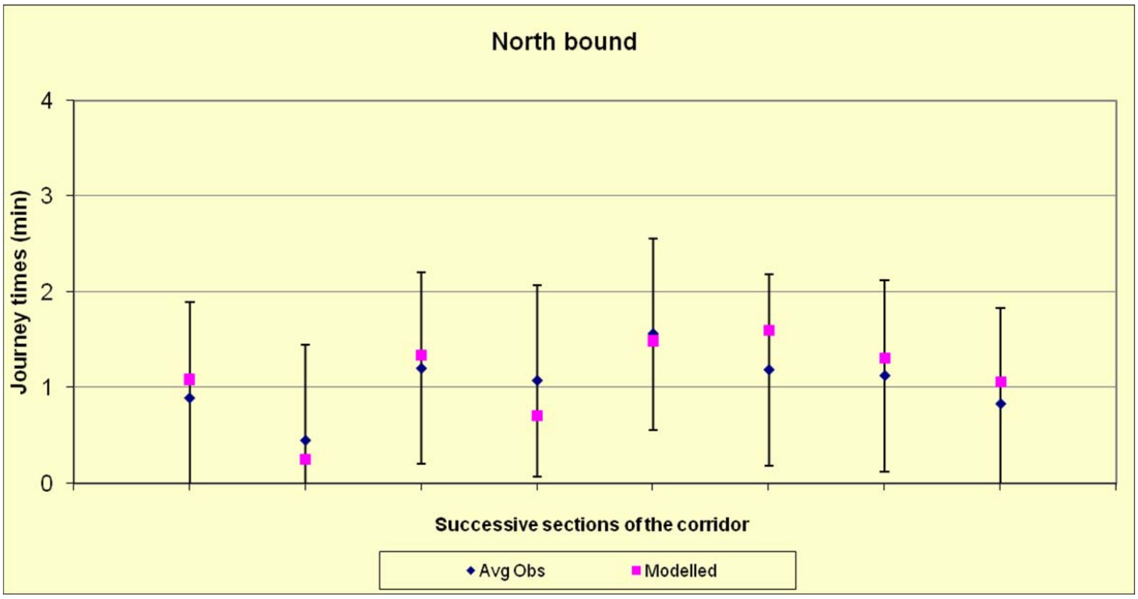



*Source: Excel calculation*

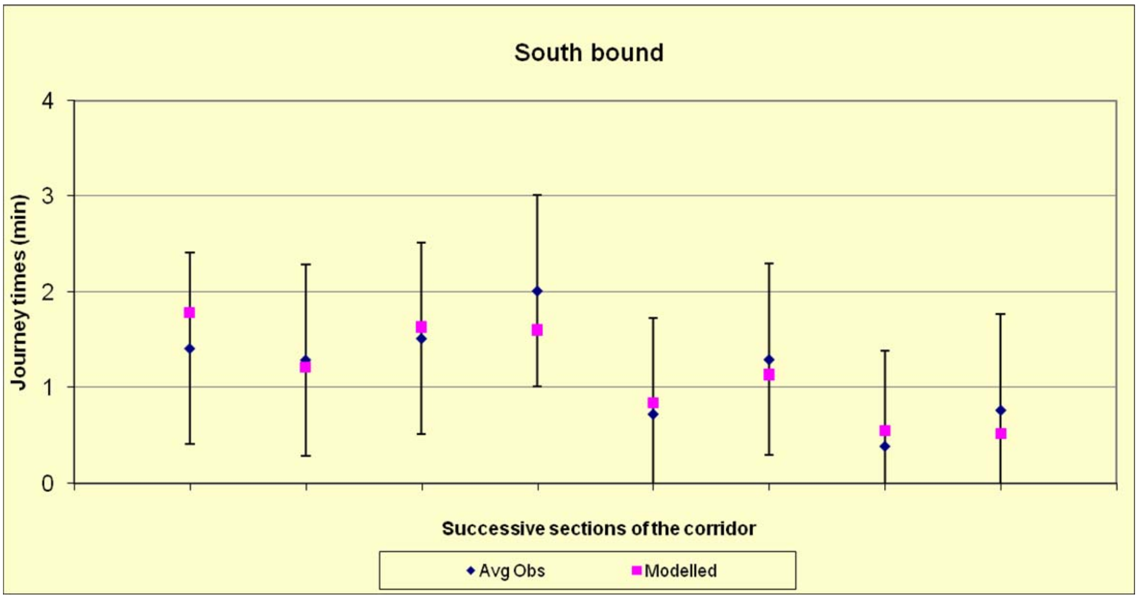



*Source: Excel calculation*

## Appendix 26: PM period average observed journey time and 1 minute boundary (north and south bounds)

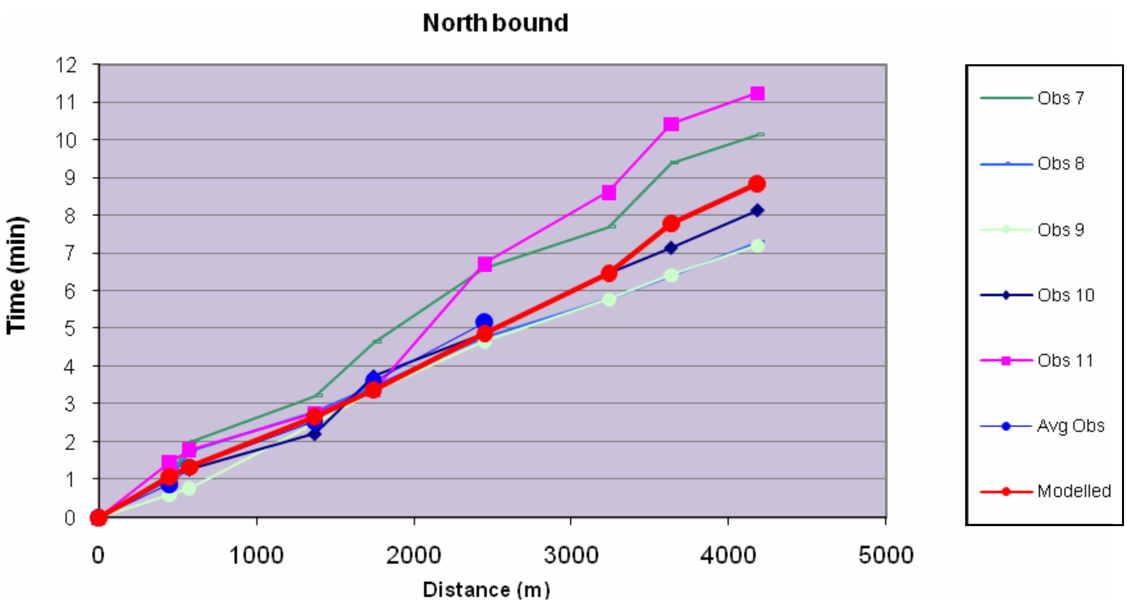



*Source: Excel calculation*

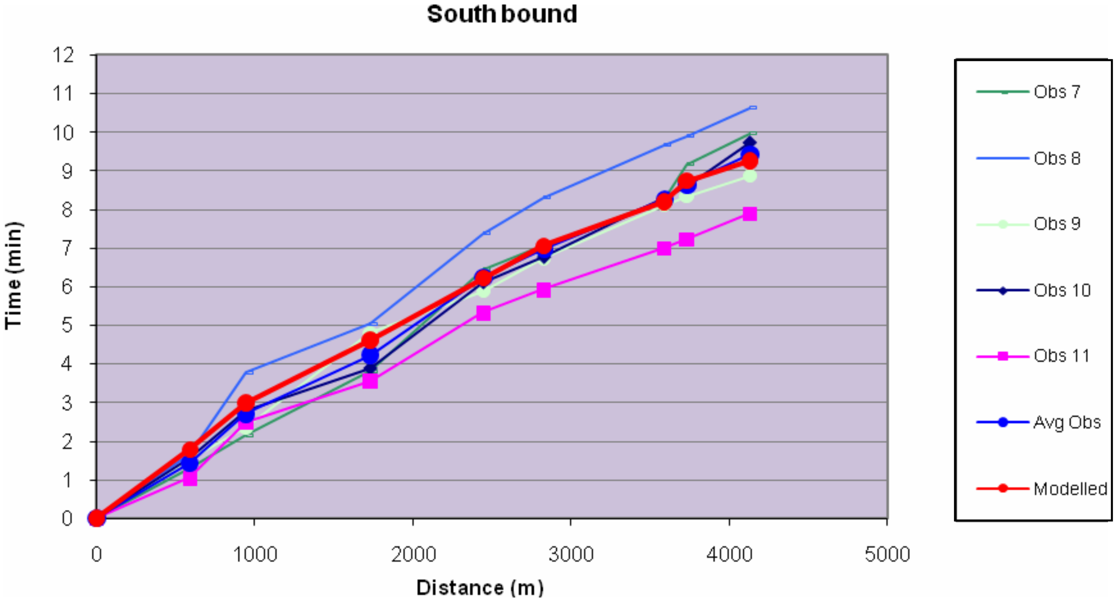



*Source: Excel calculation*

**Appendix 27: Travel times across the corridor (PM period, north and south bounds): comparison of modelled and observed values**




*Source: Excel calculation*




*Source: Excel calculation*